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KINEMATICS COMPARISON OF SQUAT (2D VS 3D ANALYSIS) FOR REMOTE LEARNING – PILOT STUDY

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Huang and Bagesteiro. Bodyweight squats are a common exercise in athletic training and rehabilitation due to their biomechanical and neuromuscular similarities to fundamental movements in a variety of sports and their requirements of coordination of major joints and numerous muscle groups (Schoenfeld, 2010). They are essential for kinesiology students, whose future careers often include athletic training and rehabilitation, to learn how to analyze the kinematics of a squat. While 3D movement analysis is considered the gold standard for motion capture (Chung & Ng, 2012), 2D digital video analysis is more commonly chosen in education environments to provide hands-on experience. However, few studies have investigated the differences between 2D and 3D analysis of squats (Escamilla et al., 2001; Krause et al., 2015; Schmitz et al., 2015). Therefore, the current study aims to compare 2D and 3D measurements of narrow-stance squats while enhancing learning by engaging students with hands-on experience using free, open-source software. Fifteen healthy adults (nine females, six males, 26.93 ± 9.04 years old) participated in this study. Following proper COVID safety guidelines, 2D analyses were performed by undergraduate students at home while 3D analyses were performed using a motion capture system in the laboratory. Lower extremity joint angles and displacements were calculated using 2D and 3D methods. Statistical significances were found when comparing the differences between both measurements except for hip flexion. Nonetheless, the resulting angular and linear measurements from both 2D and 3D analyses aligned with previous research, suggesting that 2D digital video analysis is a viable option for educational purposes despite the significant differences.

Key Words: lower extremity joints, linear and angular displacements.

Introduction

Undergraduate-level biomechanics is a core course in kinesiology curriculum that introduces the application of physics principles to the human body (Catena & Carbonneau, 2018). Courses during the COVID19 pandemic had to be moved to online learning, where most lab activities were limited to demonstrations. However, previous studies found that passively watching demonstrations was insufficient for most students to understand mechanical concepts (Crouch et al., 2004; Julian, 1995; Roth et al., 1997). Despite the instructor's efforts, students understood very little about the underlying concepts behind the demonstration (Roth et al., 1997), and observations failed to improve the rates of correct responses compared to no demonstration (Crouch et al., 2004). Various reasons contributed to this phenomenon, including students' inability to understand the important content, inaccurate connection to previous concepts and superficially similar demonstrations, low engagement, and lack of opportunity to test their ideas (Roth et al., 1997). As a result, students watching demonstrations might incorrectly interpret the phenomenon or even misunderstand observations that never occurred (Milner-Bolotin et al., 2007). On the other hand, predicting outcomes and discussing them were found to significantly improve students' understanding (Crouch et al., 2004;

Sokoloff & Thornton, 2004). Moreover, interactive lecture experiments, where students are involved in the data collection and analysis process and are responsible for discussion and solving related homework problems, were found to be greatly beneficial for students' conceptual learning and test performance (Catena & Carbonneau, 2018; Milner-Bolotin et al., 2007). The hands-on experience is so valuable in promoting student learning outcomes that it is considered to be the center of scientific education (Brinson, 2015; Ma & Nickerson, 2006). Additionally, remote laboratory activities where students complete the experimental steps at their own pace and location can offer similar benefits to in-person hands-on laboratory activities (Brinson, 2015; Cooper, 2005; Ma & Nickerson, 2006).

Practical activities are an interactive and critical aspect of the learning process. They are essential to engage students and develop problem-solving and critical-thinking skills, as well as enhance student understanding of specific topics and associating them with theoretical concepts and application. More specifically, when studying human movement, it is important to exemplify these experiences with activities familiar to the students (e.g., walking, running squatting, and reaching).

Bodyweight squats are a common exercise in athletic training due to their biomechanical and neuromuscular similarities to fundamental movements in a variety of sports (Almosnino et al., 2013; Schoenfeld, 2010). Additionally, the coordination of major joints and numerous muscle groups in squat performance allows such movement to be frequently used in rehabilitation for improvement in quality of life and evaluation of movement competency (Schoenfeld, 2010; Swinton et al., 2012). However, due to its requirements of mobility and stability of multiple joints, poor technique can lead to an increased risk of injury (Krause et al., 2015; Schoenfeld, 2010). Analyzing its kinematics can help participants understand the correct form and improve their performance. Researchers analyzed the squatting motion to gain insights into different aspects of the movement and its performance (Almosnino et al., 2013; Crowe et al., 2019; Demers et al., 2018; Esformes & Bampouras, 2013; Kim et al., 2015; Lorenzetti et al., 2018; McKean & Burkett, 2012; Moore et al., 2016; Sato & Heise, 2012; Severin et al., 2017; Sorensen et al., 2001). Also, because of its exercise efficiency, squats are often added to core exercise routines to improve lower extremity muscular endurance, strength, and overall conditioning (Escamilla et al., 2000; Escamilla et al., 2001; Schoenfeld, 2010). Therefore, it is essential for kinesiology students, whose future careers often include athletic training and rehabilitation, to learn how to analyze the kinematics of squat.

To analyze the kinematics of squat, a motion analysis technique, among others (e.g., electrogoniometer, accelerometers and gyroscopes), is a suitable method for comprehensive movement analysis. A three-dimensional (3D) motion analysis system allows assessment of multiplane measurements, with accurate tracking motion and complete description in the three body planes in a wide range of motion analysis (e.g., combined rotation, flexion, adduction movements). Two-dimensional (2D) video analysis provides a simpler technique to analyze a particular plane of motion (e.g., knee flexion and extension) under specific settings. Generally, the more elaborate the system, the higher the cost, but the better the quality of objective data that can be provided. Nevertheless, despite some limitations the simpler techniques are valuable, particularly in non-clinical settings (e.g., gym, home, workplace) where the use of high technology systems is difficult due to space, cost, and time. Additionally, the 2D method allows quantitative analysis, which can further improve the quality of visual observations.

The validity of 2D analysis is specific to the plane of motion under examination, and the particular movement performed (Alahmari et al., 2020), and few studies have investigated the differences between 2D and 3D analysis of the squat (Escamilla et al., 2001; Krause et al., 2015; Schmitz et al., 2015). While 3D movement analysis is considered the gold standard for motion capture (Chung & Ng, 2012), it is often not available for all students, especially during the pandemic. Digital video analysis has been used in physics courses since the late 1990s and was found to be an effective addition to learning kinematics and interpreting graphs (Beichner, 1996; Escalada & Zollman, 1997; Laws & Pfister, 1998). As an alternative, 2D digital video analysis using free, open-source software (Bagesteiro, 2020) can be chosen in

educational environments to provide hands-on experience. The current study aims to compare 2D and 3D motion capture measurements of narrow-stance squats for the purpose of applying the 2D technique for educational applications. This may promote students' ability to engage in practical work and identify questions and concepts that guide investigations and construct critical argument and reasoning in professional and personal settings.

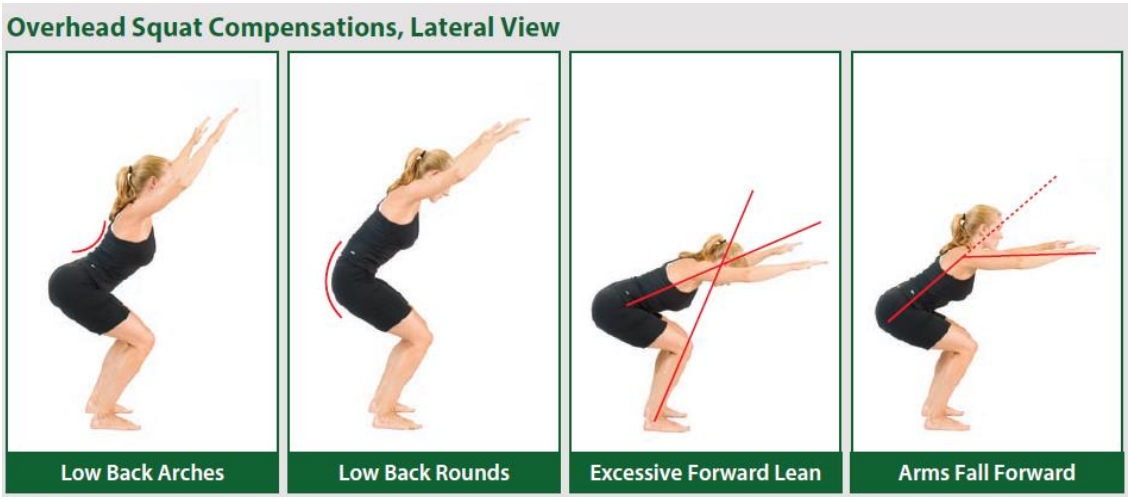
Methods

Participants

Fifteen healthy adults (nine females, six males; age 26.93 ± 9.04 years; height 1.70 ± 0.13 m; body mass 74.23 ± 18.36 kg; BMI (Body Mass Index) 25.22. ± 3.96 kg/m2) were recruited through word-of-mouth. The study was approved by the San Francisco State University ethics committee and the informed consent form was signed by each participant before the experiment. Participants' previous experience and current frequency of exercise with squats were recorded. Thirteen participants reported to be familiar with the squatting motion, only two participants had never performed a squat prior to the experiment. Additionally, seven of the 15 participants performed squatting exercises at the frequency of twice per week or more. Three participants performed squats every other week. Six participants did not engage in regular squatting exercises. Furthermore, four participants mentioned the pandemic had diminished their exercise frequency. All participants were screened to have no compensation during overhead squats (see Fig. 1) and instructed to wear skin-tight shorts or tights during data collection. The overhead assessment was performed to observe participants' overall posture and identify any related injuries or conditions (compensatory movements and muscle imbalances) that would prohibit them from safely performing a squat. Participants were instructed to perform a slow-paced squat for movement consistency across trials.

Figure 1

Overhead squat compensations (The Fitness Trainer Academy, 2015)



Experimental Procedures

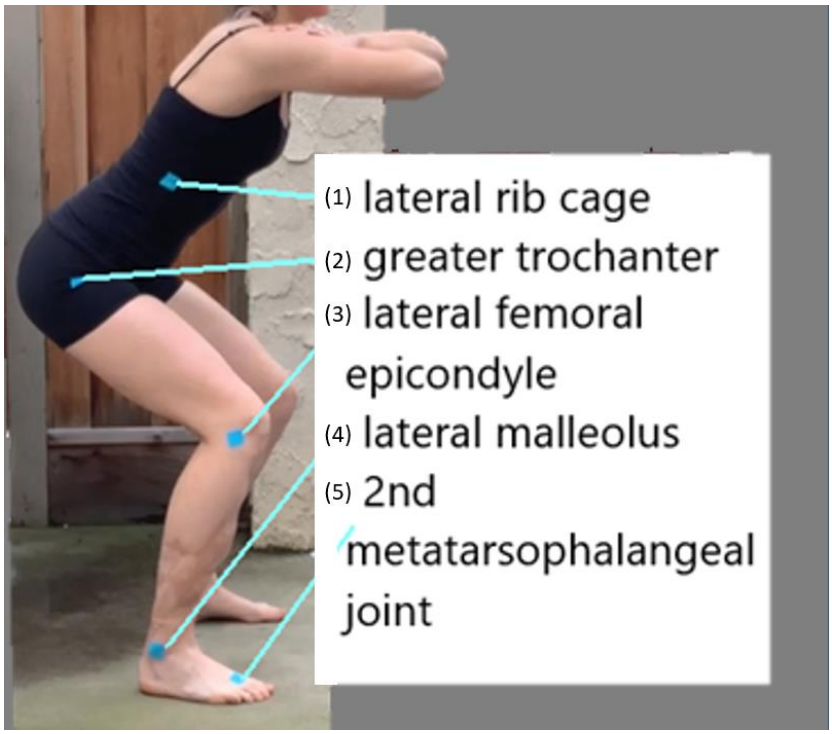
Participants visited the laboratory once and data collection was performed with one participant and two researchers present in a 93m2 area laboratory following proper COVID safety guidelines. Participants were instructed to perform squats in 3-1-3 rhythm (i.e., 3s down, 1s hold, 3s up) following a metronome set to 60 beats-per-minute (BPM). Three familiarization trials were performed, followed by the experimental trials. A narrow-stance squat was used to keep the lower limb parallel to the phone camera and avoid errors caused by image distortion. In addition, previous research showed (Escamilla et al., 2001; Hu et al., 2021) that 2D kinematic analysis is most accurate when measuring narrow-stance squat.

Two-dimensional (2D) analysis.

Five markers were attached to each side (left and right) of the participant (see Fig. 2). They included (1) lateral rib cage (midline of body), (2) greater trochanter, (3) lateral malleolus, (4) lateral femoral epicondyle, and (5) 2nd metatarsophalangeal joint. The experimental session was performed while six sagittal-view videos (three for each side, left and right) were recorded at 30 frames per second (fps) using smartphones. A rigid object of known dimensions was used to calibrate the video images. The recorded videos were processed using Tracker (a free video analysis and modeling tool – Open-Source Physics (OSP) Java framework – version 5.1.5. Brown, 2020), which was installed on researchers' personal computers. Hip, knee, and ankle angles from the sagittal plane were obtained based on Tracker analyses.

Figure 2

Marker set for 2D analysis

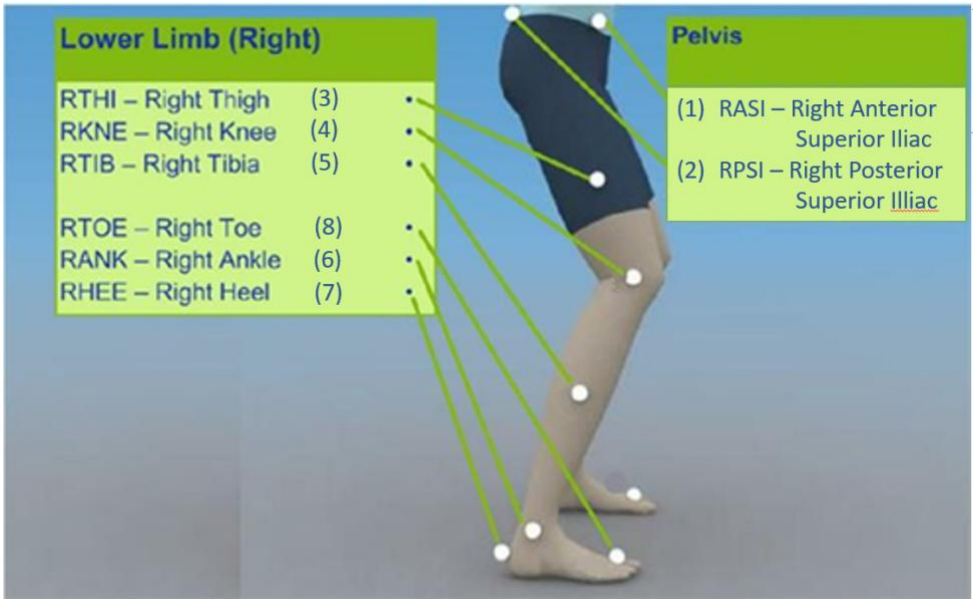


Three-dimensional (3D) analysis

A 12-camera motion capture system (Vicon Motion Systems Ltd, Oxford, UK) was used to perform 3D analyses. The Vicon motion analysis system was calibrated prior to each experimental session. Anthropometric measurements were taken and inputted to Vicon Nexus software (version 2.10.0) to scale the plug-in-gait model calculations and data processing. Participant's height and body mass were self-reported. Anterior superior iliac spine (ASIS) distance, knee width, and ankle width were measured using a caliper, and leg length was measured using a ruler. Sixteen reflective markers were attached to the participant's lower extremity, including left and right (1) ASIS, (2) PSIS (posterior superior iliac spine), (3) thigh, (4) lateral femoral epicondyle, (5) shank, (6) lateral malleolus, (7) calcaneus, and (8) 2nd metatarsophalangeal joint (see Fig.3).

Figure 3

Marker set for 3D analysis – Vicon plug-in-gait model, right side view (Vicon Motion Systems Limited, 2008)



Data processing and Statistical analysis

Movement trajectories were processed using MATLAB (R2020b) to obtain maximum changes in joint angles (hip, knee and ankle) and knee linear displacements (vertical and horizontal (antero-posterior (AP)). These joint kinematic measures are useful to describe body motions in different settings (e.g., therapists, athletic trainers, movement scientists). For each participant, joint angle data were calculated over time and normalized to total movement time for comparison. Movement start and end were set at 4% of peak hip linear displacement for both 2D and 3D analyses. The hip joint was selected because the squat is a close-chain movement, and it is the first to move. All trials were manually checked to confirm onset and termination of movement.

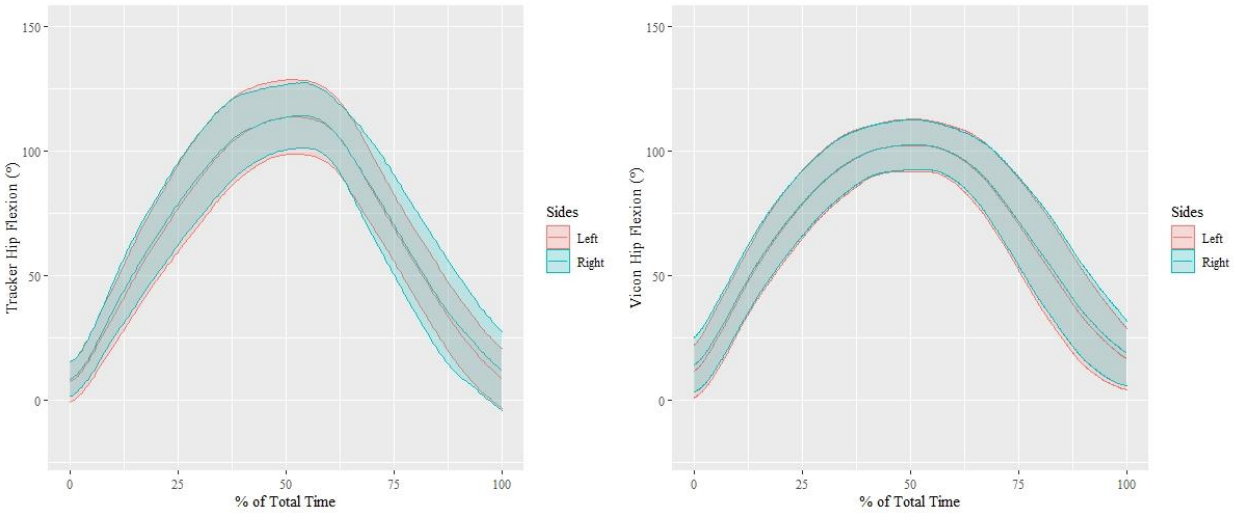
Statistical analyses on the average values of the three trials on each side were performed using R (3.6.1). Normality was assessed using Shapiro-Wilk tests, and the returned p values were all greater than 0.05 except for vertical knee displacements. Paired t-tests were used to assess the significance of paired differences for the data that satisfied the normality assumption, Cohen's d effect size was calculated, and Wilcoxon Rank Sum Test was used to assess the significance of 2D versus 3D differences in knee linear displacements.

Results

Figures 4-6 illustrate normalized (% of movement time) 2D and 3D joint angles profiles (ensemble curves (± one standard deviation (SD)) for the squat motion. The patterns of motion are similar for both Tracker and Vicon analyses. All joint angles measured by each system started between zero- and 25-degrees flexion, increased to maximum flexion at around 50% of total movement time, and decreased to near zero (start position). Furthermore, this pattern fits the 3-1-3 squatting rhythm, where participants spent most of the time in the descending (0-45%) and ascending phases (65%-100%) of the squat.

Figure 4.

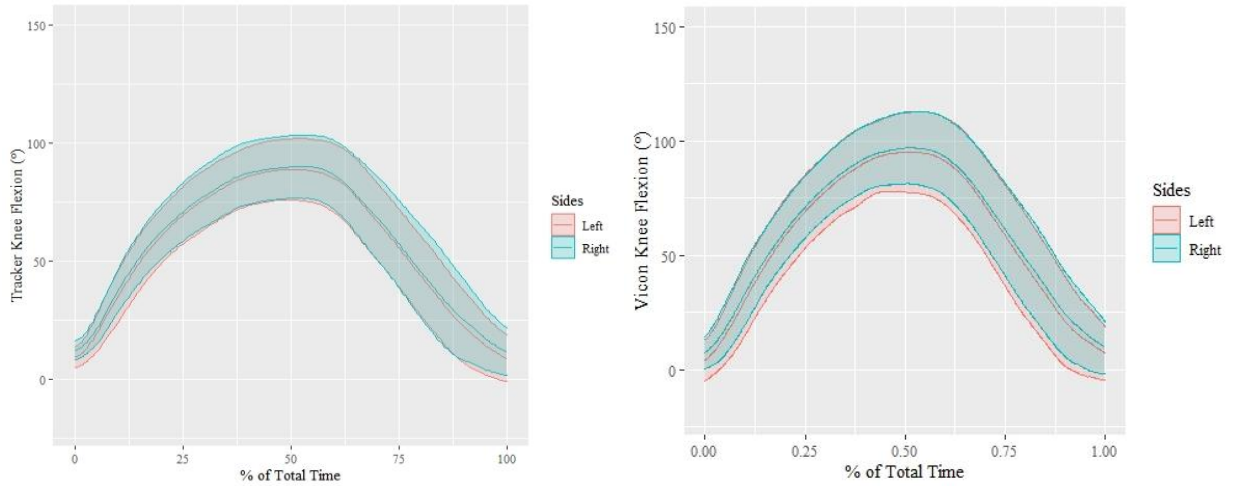
Hip flexion: comparison of 2D (Tracker, left) and 3D (Vicon, right) measures. Right (blue lines) and left (red lines) side measurements.



Note. Shadings represent ± SD.

Figure 5

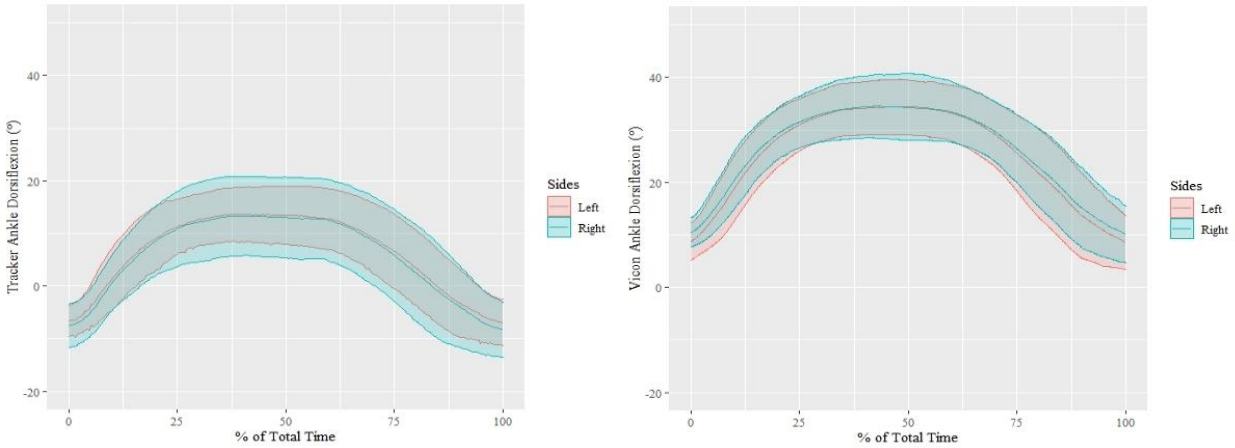
Knee flexion: comparison of 2D (Tracker, left) and 3D (Vicon, right) measures. Right (blue lines) and left (red lines) side measurements



*Note***.** Shadings represent ± SD.

Figure 6

Ankle dorsiflexion: comparison of 2D (Tracker, left) and 3D (Vicon, right) measures. Right (blue lines) and left (red lines) side measurements.



*Note***.** Shadings represent ± SD.

Statistical significances were found when comparing 2D and 3D measurements. Angular changes at all three joints measured by Tracker (2D analysis) were found to be significantly different from those measured using with Vicon system (3D analysis). Joint angles measured by 2D and 3D systems were found to be significantly different at all three joints. Hip flexion in 2D measurements (107.92 ± 12.53) was significantly greater than 3D measurements (91.45 ± 10.52) with the largest effect size ($t(29) = 6.64$, $p < 0.001$, Cohen's d = 1.47). In contrast to the higher 2D measurements in hip flexion, 2D analyses of knee and ankle angles were smaller than 3D analyses. Two-dimensional knee flexion measures (80.35 ± 12.59) were significantly smaller than 3D-measured knee flexion with a large effect size (92.63 ± 16.16, $t(29) = -7.68$, $p < 0.001$, Cohen's d = 0.85). Additionally, ankle dorsiflexion was also found to be smaller in 2D measurements (21.80 ± 5.52) than in 3D measurements with a large effect size (26.12 ± 6.72, $t(29) = -7.06$, $p < 0.001$, Cohen's d = 0.72). Knee linear measurements (antero-posterior (AP) and vertical) showed statistically significant differences when comparing 2D and 3D data, where 2D analysis consistently resulted in greater knee displacement measurements despite the direction. Tracker (2D analysis) measured greater horizontal (AP) displacements (0.22 ± 0.06) than Vicon (3D analysis) (0.15 ± 0.04), $p < 0.001$ ($t(29) = 11.89$, Cohen's d = 1.42). Vertical displacements were also greater in 2D measurements (0.12 ± 0.05) than in 3D measurements (0.07 ± 0.02), $p < 0.001$ (Cohen's d = 1.82). Mean 2D and 3D differences for all measurements are presented in Table 1.

Table 1

Mean differences between 2D and 3D angular and linear measurements (Mean ± SD).

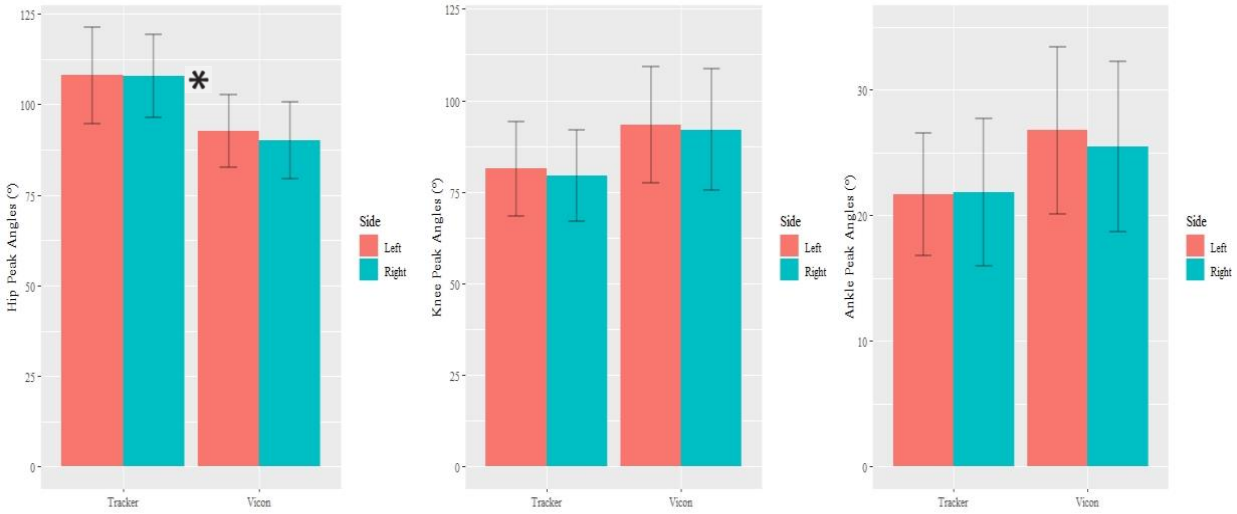
	Angular Displacement			Knee Linear Displacement	
	Hip Flexion (°)	Knee Flexion (°)	Ankle Dorsiflexion (°)	Antero-Posterior (m)	Vertical (m)
Mean Differences	16.47 ± 2.01*	-12.28 ± 3.57*	-4.32 ± 1.20*	0.07 ± 0.02*	0.05 ± 0.03*

Note. $*p < 0.001$.

Bilateral symmetry (Figures 7 and 8) was assessed using paired t-tests since all the measurements on the left and right lower limbs were normally distributed. Significance in bilateral differences were found in hip measurements. Statistical significance with a small effect size (Cohen's d = 0.26) existed for 3D hip flexion when comparing the left (92.77 ± 10.29) and right sides (90.13 ± 10.69, $p < 0.001$). However, the differences in left and right hip angles measured by the 2D system had a negligible effect size (Cohen's d = 0.02). No significant differences were found in other joint angles or knee displacements between limbs.

Figure 7

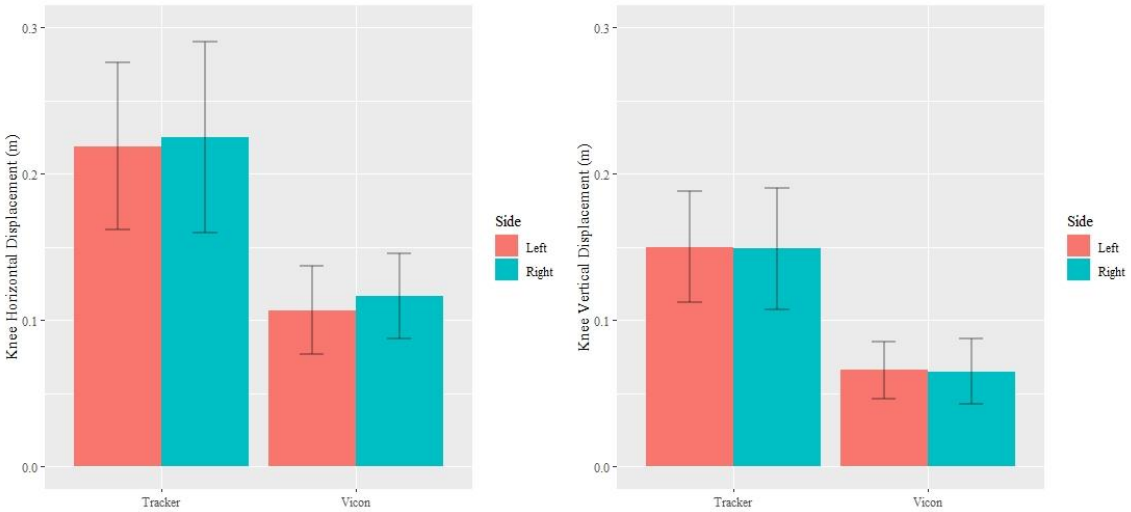
Comparison between 2D (Tracker) and 3D (Vicon) peak joint angles and right and left sides



Notes. Left chart: Maximum hip flexion; Middle chart: Maximum knee flexion; Right chart: Maximum ankle dorsiflexion.

Figure 8

Comparison between 2D (Tracker) and 3D (Vicon) knee displacements and right and left sides



Notes. Left chart: Horizontal (AP); Right chart: vertical.

Discussion

The resulting angular and linear measurements from both 2D and 3D analyses aligned with previous research. In the current study, hip flexion had an average of 106.57o (±13.38o) in 2D analysis and 91.40^{o} (± 11.60o) in 3D analysis. Both values for hip flexion fell into the range of 86.67o (± 8.30o) to 117.02o (± 9.88o) established by previous studies (Demers et al., 2018; Escamilla et al., 2001; Han et al., 2014; Mauntel et al., 2015; McKean & Burkett, 2012). Knee flexion in the current study also agreed with previous results. Past studies found that knee flexion in a narrow squat was generally between 92.67o (± 12.67o) to 147.10o (± 9.20o) (Demers et al., 2018; Escamilla et al., 2001; McKean & Burkett, 2012). While located at the lower limit of the range, both results in 2D analysis (83.24 ± 11.67o) and 3D analysis (95.29 ± 16.21o) were included in the established range. Similar to hip and knee flexion, measured ankle dorsiflexion was in alignment with earlier research. McKean and Burkett (2012), Han et al. (2014), and Demers et al. (2018) measured ankle dorsiflexion in a narrow squat to be 29.00o (± 6.00o) to 32.50o (± 5.00o), which overlapped with both the 2D angles (21.80 ± 5.52o) as well as the 3D angles (26.12 ± 6.72o). Additionally, knee 2D horizontal (anteroposterior) displacements (0.23 ± 0.06 m) supported data reported by Swinton et al. (2012) (0.22 ± 0.04 m) whereas 3D knee anteroposterior displacements (0.15 ± 0.04 m) were slightly smaller. The lesser knee flexion and ankle dorsiflexion were likely caused by reduction in physical activities during the COVID-19 pandemic since five out 12 participants reported a drop in exercise. The lack of exercise could cause a decline in lower extremity muscle strength, which was found to reduce squat depth (Kim et al., 2015).

Squat exercises are frequently regarded as a nearly symmetric task, with little difference in the movement between the two lower limbs. However, several sports require asymmetric movements, which can lead to bilateral asymmetry as a result of differences in sports-specific training and muscle strength. Bilateral differences in the hip-joint were observed; such results can be considered when attempting to decrease the risk of injury. The overall bilateral symmetry also agreed with previous studies (Moore et al., 2016; Severin et al., 2017) showing asymmetry in hip flexion reported in single-leg squats (Severin et al., 2017). The difference in hip flexion is possibly a result of lower limb dominance. Since lower limb dominance was not recorded in this study, future investigations are required to confirm such speculation. Measurements in the current study aligned with previous findings, suggesting the results to be reliable and appropriate for educational settings.

While the joint angle ranges in this study were consistent with those in past research, conflicting evidence was found on the distinctions between 2D and 3D analyses. While Escamilla and colleagues (2001) found no difference between 2D and 3D analyses of narrow squats, significant differences at all three joints were found by Krause et al. (2015), which supports our data. However, Krause et al (2015). found that the 2D software measured greater joint angles across all three joints, and the current study found that 2D joint angles were only greater at the hip and smaller at the knee and ankle joints (Fig. 6). The overestimation of hip flexion in 2D measurement is likely due to the simplification of pelvis motion (Krause et al., 2015). On the other hand, the underestimation of ankle dorsiflexion is possibly a product of camera placement. Although the camera was focusing on the lower extremities without obvious distortion, it filmed the ankle from a slightly higher angle causing the ankle to start with a false plantarflexion.

This study is not without limitations. Since this pilot study was conducted during the COVID-19 pandemic, 3D and 2D measurements were collected on two separate days as one of the necessary accommodations made to guarantee safety. Even though the squats were performed by the same subject, the subject might not have been able to repeat the same squats. Therefore, individual differences might contribute to inconsistent performances. Concurrent 2D and 3D measurements will need to be conducted to confirm the current findings. Additionally, while undergraduate students have verbally expressed their appreciation of hands-on experience over the course of this study, no testimonials were obtained. Individual or focus group interviews with a third-party can be beneficial to understand the students' experiences throughout the remote laboratory activity without any potential pressure from the instructor.

Conclusion

Kinematic analysis of the bodyweight squat is essential among various fields within kinesiology, including athletic training and rehabilitation, making squat analysis important in kinesiology curriculum. While 3D measurements are considered the gold standard and provide the most accurate results, the 2D video analysis method applied in the current study offers location flexibility (i.e., no laboratory space required) and ease of use (i.e., basic hardware and open-source software) in different learning modalities. The current study found significant differences between 2D and 3D measurements at hip, knee, and ankle joints, yet all angular measurements fell within ranges established by previous research. This investigation supports the use of such 2D video analysis as an effective tool for measuring joint kinematics and its

implementation in educational contexts. To further confirm the current findings and resolve limitations in this research, a mixed-method study with concurrent 2D and 3D recordings and focus group interviews needs to be conducted.

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BICYCLE COALITIONS AND UNIVERSITIES PRIORITIZATION OF EQUITY: WHY AND WHY NOT? A SHIFT TOWARDS MORE EQUITABLE OPPORTUNITIES

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Emily Dzieniszewski, et al. Purpose: Travel by walking or bicycling has a wide range of health benefits, from lowering the risk of obesity to all-cause mortality. Although the benefits of bicycling are well-known, there are various disparities and inequities seen in participation levels and safety in underserved and underrepresented communities (e.g., racial/ethnic minorities, women, low-income, youth, LGBTQ+). Community coalitions and universities have the potential to play a large role in reaching underrepresented populations and establishing equitable programming. The purpose of this study was to understand why equity is or isn't prioritized throughout bicycle coalition and universities' programming efforts. **Methods**: A volunteer sample of bicycle coalitions (n=71) and universities (n=51) were surveyed to identify common themes from the participants' responses regarding why or why not equity was prioritized. **Results**: Common themes among coalitions and universities who ranked equity first, was awareness of the inequality present in their communities, identified equity as an important element, and planned to prioritize equity in their programming. Common themes among those who ranked equity last was the lack of awareness, knowledge, and demand for equity-related issues. **Conclusions**: Equity is a concern for coalitions and universities. Implementation of different resources has the potential to increase equitable programming in both community and university settings.

Key Words: programming equity, bicycling, underrepresented populations, bicycle coalitions, universities, health promotion.

Introduction

Considering the array of health and community benefits that arise from AT, there are still many disparities seen based on various neighborhood and demographics. Specifically, perceptions of poorly designed neighborhoods are associated with reduced likelihood of bicycling (Heesch, Giles-Corti, Turrell, 2014). Physical environmental influences, such as the presence, proximity, and accessibility of bicycle paths/lanes, street connectivity, aesthetically pleasing neighborhoods, and time to destinations have been seen to influence AT (Panter & Jones, 2010). Due to the lack of safe streets, Hispanic and African-American bicyclists throughout the U.S. have seen a 23% and 30% higher fatality rate compared to white bicyclists, respectively (League of American Bicyclists, 2020). Similarly, the lack of safety throughout these neighborhoods and communities has led 22% of lower income populations to perceive bicycling as an activity that has the potential to lead to harassment or crime victimization (McNeil, Dill, MacArthur, Broach & Howland, 2017b).

Additionally, men have significantly higher levels of AT compared to women, which may be influenced by various social and environmental factors, such as neighborhood safety, cleanliness, incivilities, and lighting (Heesch, Sahlqvist & Garrard, 2012; Saffer, Dave, Grossman & Leung, 2013; Taylor et al., 2007). Although limited research is available, members of

the LGBTQ+ community may participate less in AT due to stereotypes and low self-esteem (Calzo et al., 2014). Underserved populations report low availability, access/affordability of bicycling equipment, as lack of bicycle storage/parking as common barriers to bicycling (McNeil et al., 2017b). In one study looking at barriers to bicycling, 41% of lower-income and racially diverse respondents, as well as 37% of white respondents claimed lack of access to equipment to be a barrier to participation, while only 13-17% of higher-income respondents reported as a barrier (McNeil, Dill, MacArthur, Broach & Howland, 2017a).

Community coalitions and universities are presented with an ideal situation to reach a large diverse population to promote AT participation (Sandt, Combs, & Cohn, 2016). Additionally, bicycle coalitions and universities may also have the opportunity to play a large role in providing equitable opportunities for underserved populations with the incorporation of the Bicycle Friendly elements. These five elements, or "E's", engineering, education, encouragement, equity, and evaluation, are consistent in making communities ideal places for bicycling for everyone (League of American Bicyclists, 2021b). Coalitions typically operate as non-profit organizations that work towards establishing equal bicycle access for all populations and improving the safety of communities' infrastructure (Bicycle Coalition of Greater Philadelphia, 2021; Bopp et al., 2017). Members and leaders of the coalitions help advocate for policies, educate the community about bicycling, and support various other advocates to increase bicycling in their local communities (New York Bicycling Coalition [NYBC], 2021). Moreover, universities may collaborate with their local community to enhance equity in both student and community populations. The defined boundaries and unique environment of a university makes it the ideal place to incorporate bicycling (League of American Bicyclists, 2021a). Over the recent decade, U.S. higher education universities have noted increases in diversity (e.g., race/ethnicity, income, gender identity, sexual orientation, and age) in their enrollments and may require proper resources and supportive bicycling environments to assist this growth (de Brey et al., 2019; Dill, 2009; Smith et al., 2017).

Previous mixed-methods studies have suggested that universities and coalitions lack the organizational capacity to reach underserved populations throughout their campus/community (Elliott, Wilson, & Bopp, 2021; Elliott & Bopp, Under Review a, b, c). Barriers in reaching underserved and diverse populations were a lack of diversity in coalition leadership and membership, a lack of trust between coalitions and underserved communities, and a lack of personnel and finances. Motivators and best practices were partnering with off-campus organizations, conducting needs assessments, diversity, equity and inclusion training, and connecting community/university infrastructures (Elliott et al.; Elliott & Bopp, Under Review a, b). The purpose of the current study was to qualitatively examine and understand why bicycle coalitions and universities throughout the United States prioritize equity last, or first, in their organization/institution's bicycle programming efforts.

Methods

Participants and Procedures

A web-based survey (Qualtrics, Provo, UT) was sent out to bicycle coalitions and universities throughout the United States, as described in previous studies (Elliott et al., 2021; Elliott & Bopp, Under Review c). Coalitions (n = 287) and Universities (n = 123) were identified for distribution through the League of American Bicyclists (LAB) website (League of American Bicyclists, 2021), a national advocacy organization which incorporates a Bicycle Friendly America Program, which recognizes efforts for promoting and providing a more bicycle friendly environment in Bicycle Friendly Communities (BFC) and Bicycle Friendly Universities (BFU). Currently, there are 487 BFCs, as of May 2021, and 212 BFUs, as of February 2021 (League of American Bicyclists, 2016; League of American Bicyclists, 2021a). Their efforts are evaluated in five primary areas, known as the "Bike Friendly E's": engineering, encouragement, education, evaluation, and equity (League of American Bicyclists, 2021a).

Emails were gathered from coalition and university websites from executive directors, general information individuals, and sent to alternative transportation and/or bicycling department

representatives. Participants received a description of the survey as well as a hyperlink to access the survey in an email. Informed consent was presented to the coalition participants when opening the link to the online survey. The response rate was 33.1% (n = 95) for coalitions and 48.8% (n = 60) for universities. Incomplete survey data was discarded, resulting in a completion rate of 74.7% and a final sample of n = 71 for coalitions, and a completion rate of 85% and a final sample of n = 51 for universities. The Pennsylvania State University Institutional Review Board approved this study.

Measures

Description of Biking-related Community and University Demographics

Participants were asked to describe their community's and/or university's League of American Bicyclists (LAB) Bicycle Friendly Community (BFC) recognition level (none, honorable mention, bronze, silver, gold, platinum). The names and additional demographics of the coalitions and universities were excluded for anonymity.

Bicycle Friendly E's

Participants (both coalition and universities) ranked the five E's (elements) of bicycle friendliness (engineering, education, encouragement, equity, and evaluation) that their organization prioritized the most (1 being the most, 5 being the least). Only the participants who ranked equity first or last then answered an open-ended question to explain the prioritization of equity in their programming. Participants who ranked equity as 2, 3, or 4 were not asked to explain their prioritization and were not used to identify common themes among the responses.

Data Analysis

Data were analyzed using SPSS version 26.0 (IBM, Armonk, NY, USA). Basic frequencies and descriptive statistics were used to describe the sample. Qualitative coding and thematic analysis were completed using Atlas.ti Version 8.4.5 (Berlin, Germany).

Results

Common themes were identified from the participants' responses regarding why or why not equity was prioritized. These themes are outlines below, considering the organization/institution's LAB BFC/BFU recognition level (none, honorable mention, bronze, silver, gold, or platinum). University and community type, as well as full frequencies of LAB recognition level for BFU's and BFC's can be found in Table 1.

Table 1

University (BFU) and Community (BFC) Demographics

	BFU		BFC	
	n	%	n	%
University Type				
National or Regional University	42	85.7		
Liberal Arts College	4	8.2		
Baccalaureate College	1	2.0		
Community college	2	4.1		
Type of Community Served				
City/Town			22	31.9
Entire County			18	26.1
Region w/ Several Cities/Towns			17	24.6
Entire State			12	17.4
LAB Bicycle Friendly America Program Recognition Level				
None	1	2.0	17	29.8
Honorable Mention	1	2.0	5	8.8
Bronze	12	24.0	20	35.1
Silver	17	34.0	10	17.5
Gold	12	24.0	1	1.8

Platinum	7	14.0	4	7

Note. LAB = League of American Bicyclists; BFU = Bicycle Friendly University; BFC = Bicycle Friendly Communities

Participants Ranking Equity Last

Coalitions: Of the 71 coalitions that participated in the survey, 12 ranked equity last (five bronze, three none, and four statewide). The responses from the participants made it evident that these organizations have not put much attention on equity, especially since one participant responded that "the demand had not presented itself". Small populations, low funding, lack of diversity within the staff and the community, and new leadership, were common issues for coalitions to consider equity a priority. Lastly, one coalition representative states that they were "not sure what equity means," indicates that equity is completely unknown to some organizations. Illustrative quotes for coalitions ranking equity last can be found in Table 2.

Universities: Of the 51 universities that responded to the survey, 13 universities ranked equity last (two bronze, four silver, four gold, and three platinum). Some universities did not see an equity issue within their communities claiming that they believe "there is already equity in the bicycle environment on the campus and in the city." On the other hand, other universities are working towards adjusting their institution to improve equity. A lack of resources and proper framework seem to be holding universities back, but there is hope with universities "working to change" their programs to provide more equitable opportunities. Illustrative quotes for universities ranking equity last can be found in Table 2.

Table 2

Illustrative quotes from university and community participants who ranked Equity last

LAB Recognition		***Illustrative Quote***
Bronze	BFU	*"Our biking resources are open to all and there are no major equity issues."*
Bronze	BFU	*"Our population isn't very diverse to begin with so outreach to underrepresented sectors."*
Silver	BFU	*"We believe that there is already equity in the bicycle environment on the campus and in the city."*
Silver	BFU	*"We haven't had the capacity to develop relationships to focus more on equity."*
Silver	BFU	*"Equity is a new E, it wasn't on the application in 2019 when we last applied. We previously addressed Equity as an integral part of Encouragement."*
Silver	BFU	*"There are not consistent programs to make biking more affordable and accessible to all people."*
Gold	BFU	*"Hasn't been a framework in place to address this. Our department is currently working on an equity assessment of our transportation programs."*
Gold	BFU	*"We are working to change this."*
Gold	BFU	*"Unfortunately, we do not have any programs targeted specifically at underrepresented groups"*
Platinum	BFU	*"Hardest to manifest with our current resource allocation"*
Platinum	BFU	*"Equity is more nuanced area that we work on similar to the others, but still has underrepresented groups."*
Platinum	BFU	*"I think we don't do a good job on focusing on underrepresented communities."*
None	BFC	*"The demand has not presented itself."*
None	BFC	*"Our limited resources dictate a "general population" approach, and we focus more specifically on underrepresented or disadvantaged populations when opportunities arise to assist the projects of larger organizations. Such as the County Health Department and Building Healthy Communities. program."*
Bronze	BFC	*"Very small population of low-income families/people in our community."*
Bronze	BFC	*"Not sure what equity means."*

Bronze	BFC	*"We believe everyone is equal, we have no focused much on this as it hasn't been an issue, but something that needs to addressed."*
Bronze	BFC	*"Lack of diversity on staff/board means fewer relationships in other communities which hampers ability to connect with and serve them (currently staff & board are ALL white, staff is 80% women)."*
None	BFC	*"Priorities."*
None	BFC	*"It goes along with everything so it's less a focus than a constant consideration."*
None	BFC	*"Because we have yet to address as an organization. Just beginning these conversation under new leadership."*
None	BFC	*"No matter what funds we have, we have a heart for the people."*
None	BFC	*"State DOT does not have the resources or staff."*

Note. LAB = League of American Bicyclists; BFU = Bicycle Friendly University; BFC = Bicycle Friendly Communities

Participants Ranking Equity First

Coalitions: Of the 71 coalitions that participated in the survey, five coalitions ranked equity first (two bronze, one silver, one gold, and one platinum). These coalitions mentioned that their previous approaches were "reinforcing the racial inequalities in access to safe, affordable and sustainable transportation," and have "recently made a shift focusing clearly on equity." Some of these coalitions have noted what they have done already in hopes of minimizing these disparities. For example, one participant responded that their organization runs "a bike recycling program where we provide a bike, lock, helmet, lights, and basic safety education to people in need." Illustrative quotes for coalitions ranking equity first can be seen in Table 3.

Universities: Of the 51 universities that responded to the survey, two universities ranked equity first (one bronze and one silver). These universities aimed to have access for students, faculty, and staff on their campuses. A major priority was "making sure our university has access for all". Illustrative quotes for universities' ranking equity first can be seen in Table 3.

Table 3

Illustrative quotes from university and community participants who ranked Equity first

LAB Recognition		***Quote***
Bronze	BFU	*"Providing an equitable service such as a bike share program that is open to all students, faculty, and staff for free is the low hanging fruit, and easiest to put into motion quickly and efficiently"*
Silver	BFU	*"Making sure our university has access for all."*
None	BFC	*"Equity is now centered in all of our work."*
Bronze	BFC	*"Our county has a high poverty rate, and nearly 10% of people lack access to a motor vehicle. We run a bike recycling program where we provide a bike, lock, helmet, lights and basic safety education to people in need."*
Bronze	BFC	*"We have recently made a shift to focusing clearly on equity before engineering. We have made this change due to a recognition that our previous approach was reinforcing the racial inequities in access to safe, affordable and sustainable transportation."*
Platinum	BFC	*"Because it's where we're most lacking."*

Note. LAB = League of American Bicyclists; BFU = Bicycle Friendly University; BFC = Bicycle Friendly Communities

Discussion

Community coalitions and universities are important resources for promoting healthy behavior, including AT, throughout populations across the U.S. In both communities and universities, bicycle ridership as a form of AT and recreation has shown to produce many health benefits for individual health, community health, and economics (Chapman et al., 2018; Hamer & Chida, 2008; Sauders et al., 2013). In university settings, behaviors set in college have the

potential to continue into adulthood, making it important to promote AT and active lifestyles (Bopp et al., 2021). However, the needs of all populations are potentially not being met as a result of equity being one of the lowest priorities of both community and university settings. Underrepresented populations (racial/ethnic minorities, women, low-income, youth, LGBTQ+ communities) show lower rates of AT due to a variety of social and physical environmental factors (Ogilvie, Mitchell, Mutrie, Petticrew & Platt, 2008). This current study has identified and suggested some of the common themes why organizations/institutions are ranking equity as first or last, to propose recommendations to establish equitable environments.

Among the organizations/institutions that ranked equity first, it was commonly seen that there was an awareness of the inequality present in their communities. Each of these organizations identified equity as an important element and planned to prioritize equity in their programming. Common themes among organizations/institutions who ranked equity as their last priority was the lack of awareness, knowledge, and demand for equity-related issues. Considering the difference in prioritization of equity in both community and university settings, the lack of implementation and programming towards underrepresented populations needs to be addressed to meet equity. If no efforts are made towards improving this issue, then various populations are at risk of long-term negative health outcomes (Saunders et al., 2013).

Several interventions and strategies have the potential to increase bicycling in community and university settings. Studies have shown that multi-component interventions that are participatory rather than informational have been found to be more effective in long term behavior change (Page & Nilsson, 2016). Community-wide campaigns (Task Force on Community Preventive Series, 2001b), increasing access to places that promote physical activity (Task Force on Community Preventive Series, 2001c), and behavioral and social support interventions (Task Force on Community Preventive Services, 2001a), have successfully increased overall community and individual physical activity, including bicycling. Additionally, improvement strategies focusing on changes with policies, social norms of an organization/institution, and the physical environment can improve equity (Centers for Disease Control and Prevention [CDC], 2013). In university settings, institutions can organize student representatives with staff representatives from relevant departments (e.g., planning, housing, transport, police, etc.) to resolve issues pertaining to AT on campus (U.S. Department of Health and Human Services [HHS], 2020; Wilson et al., 2018). Federal legislation, such as Title IX (gender-based equity) and ADA (ability-based), also mandates diversity, equity, and inclusion on campuses (United States Department of Justice, 2001, 2010).

Organizational practices are an important area to target as well to make improvements. Organizations and institutions can benefit from diversity, equity and inclusion training by learning how to build culturally tailored events/programs for the community or reach underserved population through effect communication techniques (Buse, Bernstein, & Bilimoria, 2016; Elliott et al., 2021). Forming partnerships with local authorities, agencies, workplaces, on and off-campus organizations increases effective programming as connections are expanded and the needs of all populations within the community are addressed (Davis & Petrokofsky, 2016; Brinkerhoff, 2002; Elliott et al.,2021).

Despite the findings from the related study, there are numerous limitations. Questions from the survey were all self-reported, which could present biases or misrepresentation. Participation was voluntary, which could lead to response bias. Another limitation is the knowledge of the coalition or university depends on the participant's experience with that organization. Lastly, the small sample size limits the ability to gauge complete differences in coalitions and universities across the United States. Future research should attempt to use different methods to understand the best practices for providing equitable bicycling programming to underrepresented populations in community and university settings. Since coalition and university demographics were not included in the study, future studies should investigate what demographics relate to equitable programming as well as other potential impacting factors, like equity training. We hope to inform organizations/institutions about these common themes to consider adopting interventions and

strategies to provide equitable opportunities for all populations in their communities.

Conclusion

Bicycle coalitions and universities are key tools for increasing active travel across all populations in the United States. Although many benefits have been seen with AT, many underrepresented populations (racial/ethnic minorities, women, low-income, youth, LGBTQ+) do not participate due to several societal and environmental factors. Results from this study suggest that equity is a concern for coalitions and universities. Common themes identified among coalitions and universities that did not prioritize equity were lack of awareness, knowledge, and demand for equity-related issues. Many participants do not know how to improve this issue in their programming. These results suggest that implementation of different resources, such as community-wide campaigns, behavioral and social support interventions, and physical environment improvements, have the potential to increase bicycling equity in both community and university settings and impact health disparities within the greater population. By identifying the common themes among coalitions and universities and providing potential strategies, we hope that equity increases in bicycle programming in both settings.

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CITATIONS IN *GOOGLE SCHOLAR* PROFILES BY KINESIOLOGY SUBDISCIPLINE

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Knudson. Keywords are important bibliometric tools for classifying, accessing, and summarizing research. Communication in and external recognition of kinesiology research may be limited by inconsistent use of terms. Citations to the top twenty Google Scholar (GS) Citations Profiles were retrieved for 20 kinesiology-related subject keywords used as GS "labels". Total citations to top scholars were largest for the disciplinary labels "physical activity," "exercise," "physical education," "sport science," "sports," "exercise science," "sport," and "kinesiology." Citations to top scholars using professional labels were in "sports medicine" and "coaching." The results confirm previously reported trends of slow growth of use of the term kinesiology primarily in the United States even though the highest citations were to the "physical activity" focus of the field. Strong citation counts to the "exercise," "physical education," and "sport science" GS labels likely result from the diversity of research interests in the field throughout the world. Kinesiology-associated scholars are influential leaders contributing to a majority of highly cited research using kinesiology subdisciplinary keywords as labels in GS Profiles. The study confirmed previous research of inconsistent use of the terms "sport" and "sports." Inconsistent use of terms and keywords are a barrier to recognition of and the search for kinesiology-related research.

Key Words: exercise science, keywords, research line, sport, subject area.

The academic discipline of kinesiology has developed from physical education units in higher education (Knudson & Brusseau, 2021; Renson, 1989). After the 1960's this interdisciplinary field, focused on physical activity or voluntary human movement (Newell, 1990), has continued to grow in diversity of subdisciplinary and professional applications (Greendorfer, 1987; Hoffman, 1985; Lawson, 1991; Lawson & Kretchmar, 2017; Newell, 2021; Thomas, 1987). Over 150 years ago most physical education (a.k.a. kinesiology) research focused on anthropometrics, measurement of fitness and physiological parameters. Other early physical education researchers adapted many "parent" disciplines into unique and somewhat-unique, kinesiology research subdisciplines (e.g., biomechanics, motor development, motor learning, sport and exercise psychology). Examples of recent subdisciplines that have established journals and a relatively consistent nomenclature are physical activity epidemiology, sports analytics, and sports nutrition.

Despite a long history of contributions to physical activity knowledge, the field of kinesiology continues to struggle with academic recognition in academe (Henry, 1964; Knudson, 2016; Kretchmar, 2008; Renson, 1989; Rikli, 2006; Sage, 2013). Kinesiology faculty can publish their research in "parent" discipline, subdisciplinary or multidisciplinary kinesiology journals (Schary & Cardinal, 2016). Whatever the publication outlet, the scholarly use of research is often assessed in academe using citations in subsequent, indexed peer-reviewed publications (Bornmann & Daniel, 2008; Knudson, 2019b). It is

important to remember that bibliometric citations represent academic usage in subsequent scholarship, not impact or quality of the journal or article (Bollen et al., 2009; Franceschet, 2010; Knudson, 2013; Patience et al., 2007; Zhou et al., 2012). Analysis of citation totals also depend heavily on the bibliometric database used (Bar-Ilan, 2018; Harzing, 2019; Martin-Martin et al., 2018, 2021; Rovira et al., 2019), keywords, subject areas, electronic search engine properties, and user skill in searching (Gusenbaur & Haddaway, 2020; Hjørland,2015; Vaughan & Thelwall, 2004).

Despite the complexities of bibliometric indexing, searching, and citation metrics the scholarly visibility and usage of kinesiology research can be examined by analysis of kinesiology-related keywords and citation data. Analysis of keywords related to kinesiology may be important to understanding the visibility and use of research by kinesiology scholars (Knudson, 2022a, 2022b; Morrow & Thomas, 2010; Rikli, 2006). Knudson (2020a) studied 100 kinesiology journals using Web of Science and reported differences in citation rates across kinesiology subdisciplines and database-assigned subject areas. In a subsequent study, Knudson (2020b) examined twenty keywords used for kinesiology department names in Google Scholar Profiles and found inconsistent use of terms in the field based on citations. The purpose of this study was to describe the citation patterns among top scholars using common kinesiology-related subdiscipline keywords to describe their research interests and examine the representation of kinesiology scholars in these subdisciplines.

Method

The GS database was selected for this study because it provides the largest, most comprehensive coverage of scholarly publications of all bibliometric databases (Delgado-Lopez-Cozar & Cabezas-Clavjo, 2013; Gusenbauer, 2019; Halevi et al. 2017: Harzing & Alakangas, 2016; Martin-Martin et al., 2018, 2021; Meho & Yang, 2007) and this is particularly important in a diverse, multidisciplinary field like kinesiology. The GS Citations function has a "Profiles" feature that allow registered users to create citation reports, correct/curate their indexed records, and network with other scholars. Scholars with a GS Profile can select up to five "labels" that serve as keywords describing their areas of research interest. Research using GS Profiles has reported that analysis of keywords used as GS labels provide an understanding of real meanings of research areas that can inform typical database-generated subject categories (Ortega & Aguillo, 2012). GS Profiles also have greater coverage and citations than other scholarly networking sites like Academia.edu, Microsoft Academic Search, or ResearchGate (Ortega, 2017; Ortega & Aguillo, 2014). Knudson (2022b) studied the top ten GS profiles for scholars using twenty general terms used as GS labels aligned with the whole field of kinesiology and found the most citations for "physical activity," "exercise," "physical education," "sport science," "sports," "exercise science," "sport," and "kinesiology."

The current study searched GS Profiles using 20 kinesiology subdisciplinary keywords as GS labels (Table 1). The kinesiology subdisciplinary terms were selected to follow terminology traditions in the subdisciplines of the field as closely as possible (e.g., "label:sport_management") while ensuring the most citations documenting usage and academic visibility in the top twenty GS Profiles. Similar to previous research (Knudson, 2022b), some GS users favor the use of keywords as labels in inconsistent patterns. In contrast to sport management, "sports" was favored over "sport" with the label "sports_nutrition" having the most citations. Another example was the common subdisciplinary name as a GS label "label:sport_and_exercise_psychology" had fewer GS profiles and profile citations than "label:sport_psychology".

Two common kinesiology subdisciplinary searches were somewhat problematic. The search for "label:measurement" was used because there was only one GS profile for the well-known kinesiology subdiscipline of measurement and evaluation: "label:measurement_evaluation" and substantially fewer citations to profiles using "label:measurement_and_evaluation". Two searches were combined ("label:sport_philosophy" and "label:sports_philosophy") for sport philosophy and returned only 11 of the targeted 20 profiles. The dearth of sport philosophy scholar participation in GS Profiles is consistent with the reasoned rejection of citation metrics by philosophy scholars (Feenstra & Lopez-Cozar, 2022).

Table 1

Citation data for the top 20 Google Scholar (GS) Profiles using Kinesiology Subdisciplinary Labels

GS Label (Total *GS* Profiles)	Total C	75%	M_e	25%	γ	PR	PTC
Athletic_Training (122)	85,189	2,786	1,580	1,401	2.9	95	98
Biomechanics (6,895)	850,559	51,907	40,992	34,986	0.3	30	18
Exercise_Physiology (2,315)	880,097	47,309	33,966	26,324	2.9	60	47
Fitness (300)	216,544	12,197	6,757	4.083	1.7	60	46
Measurement (892)	811,121	64,745	23,919	17,373	1.3	0	0
Motor_Behavior (102)	25,168	1,545	1,041	777	1.2	50	52
Motor_Development (208)	216,635	12,799	8,443	6,278	2.4	70	77
Motor_Learning (636)	484,195	27,429	16,992	12,133	2.2	40	37
Physical_Activity_Epidemiology[ᵛ]	176,845	9,696	3,864	1,615	4	50	70
Physical_Education (1,643)	535,686	22,944	13,705	11,417	4.2	100	100
Sports_Analytics (166)	274,556	14,997	5,714	2.854	3.8	45	10
Sports_Coaching (49)	20,653	1,539	613	245	1.8	90	58
Sports_History (46)	35,574	1,485	371	200	2.8	20	55
Sport_Management (728)	150,828	8,632	6,392	5,109	1.5	70	73
Sports_Nutrition (268)	250,326	12,907	7,700	5,590	1.8	60	54
Sport_Pedagogy (112)	46,525	3,355	1,941	1,247	0.9	75	85
Sport(s)_Philosophy [*](11)	1,874	445	23	1	1.5	100	100
Sport_Psychology (667)	374,410	26,463	13,092	9,560	0.9	65	72
Sport_Sociology (73)	24,171	1,603	459	299	2	70	46
Strength_and_Conditioning (272)	203,347	11,025	7,264	4,380	3.3	95	97

Note. Top 20 GS profile data for either "sport" or "sports" were based on the most total citations, except for philosophy[*] where the 11 profiles were reported combining searches for "label:sport_philosophy" and "label:sports_philosophy". [ᵛ]Total GS Profiles for physical activity epidemiology was n =34. PR is percentage representation of top scholars with kinesiology-related department/unit affiliation (see operational definition in methods) and PTC is percentage total citations representation by these same scholars. Searches completed by March 10, 2022.

Searches were completed by March 10, 2022. To get a sense of the size of each of the 20 kinesiology-related subdisciplinary terms used as GS labels, the author sought out the total number of scholars with GS Profiles using those labels (Table 1). Obtaining a total number of profiles using these labels required onerous manual retrieval of records ten at a time until a final profile was found.

GS citation data were extracted for the top 20 scholars and total citations for each were entered into Microsoft Excel. Images of the returned records were captured and stored to assist in scholar identification, data cleaning, and analysis. In addition to total citations, the investigator classified each scholar as either affiliated with kinesiology or "other" disciplinary department or professional unit. Kinesiology-related affiliations included all variations of health, physical education, recreation and dance; human movement; exercise and sport studies variations of department/unit names for the field (Baker et al., 1996; Custonja et al.,2009; Knudson, 2022b). This qualitative classification of affiliation was based on data in the GS profile and internet searches of university/unit, ResearchGate, Facebook, or corporate websites. Scholars with corporate/consulting positions or in graduate training were classified as kinesiology if at least a master's degree in the field had been completed. Scholar affiliation was primarily based on employment as there were several scholars with doctoral and post-doc training in kinesiology but were classified as other disciplinary affiliation given their appointment in medical, therapy, or dietetic departments. Affiliation for one scholar could not be determined and was, therefore, classified as other discipline.

Descriptive statistics were calculated for all dependent variables with JMP Pro 14 (SAS Institute, Cary, NC). Total citations, median, and 75th and 25th percentile were reported given the high skew (γ = 2.2 ± 1.1) of the citation data. Qualitative comparisons of the total citations and median citations were made across subdisciplines given the descriptive nature of the study and heavily skewed citation data. Citation data represent scholarly usage (Bollen et al., 2009; Franceschet, 2010; Knudson, 2013, 2019b; Zhou et al., 2012) and also the visibility of research in the scientific community. In addition, the classification of each scholar was used to calculate two kinesiology representation variables: Percentage representation (PR) was the percentage of top twenty GS Profiles with kinesiology affiliations and percentage total citations (PTC) was the percentage of their citations to the total citations to the top twenty GS profiles. PTC was the percentage of total citations that were attributed to kinesiology-affiliated scholars. Qualitative description and comparisons of the kinesiology representation variables excluded the subdiscipline of "measurement" given no kinesiology-affiliated scholars were ranked in the top 20 records.

Results

Citation totals to the top twenty GS Profiles were highly skewed (γ) for all subdisciplines except biomechanics (Table 1, Column 6). There was great variation in total and median citations to the top GS Profiles between the subdisciplines of kinesiology used as subject area labels. Kinesiology subdisciplinary terms as GS labels with the most citations, excluding measurement, were exercise physiology, biomechanics, physical education, motor learning, and sport psychology. Biomechanics had the highest median citations (40,922) that was 110 and 1782 times greater than sport philosophy and sport history, respectively. Four of the subdisciplines had fewer than 73 total scholars with GS Profiles [sport sociology, sports coaching, sports history, and sport(s) philosophy], while the three largest numbers of profiles were for biomechanics (6,895), exercise physiology (2,315), and physical education (1,643).

The majority of scholars with a GS Profile using kinesiology-related subdisciplinary labels were affiliated with kinesiology departments/units. Excluding measurement, only biomechanics, motor learning, sports analytics, and sports history had kinesiology PR below 50% (Table 1). Mean and variability of PR of kinesiology in the subdiscipline labels (67 ± 24%) were similar to the percentage of total citations (PTR) to those kinesiology scholars (64 ± 27%).

Discussion

Searching GS for twenty common kinesiology subdisciplinary terms used as a subject "label" in GS Profiles returned widely varying citations across subdisciplines. Subdisciplines with large total citations (535,686 to 880,097) for the top twenty GS

profiles were exercise physiology, biomechanics, and physical education. These were 36 to 470 times larger than sport sociology, sports coaching, and sport philosophy. The large variation in citation patterns between different academic disciplines is a common observation and means they cannot be compared across different fields of scholarship (Declaration on Research Assessment [DORA], n.d.; Hicks et al., 2015; Patience et al., 2007; Podlubny, 2005; Seglen, 1992). This large variation in citation patterns between subdisciplines within kinesiology has also been reported along with the additional confounding factor of strongly skewed citation data (Knudson, 2014; 2015a, 2015b, 2022a).

The total citations to the 20 kinesiology subdisciplinary GS labels were strongly skewed in all subdisciplines, except biomechanics. The large skew makes mean citation metrics like the Web of Science impact factor biased and inaccurate, however even use of median data show major differences between subdisciplinary citation patterns in kinesiology. Examination of median citations showed even large differences (89 to 1782 times) from top three to bottom three subsdisciplines. It is clear that comparisons of citation data must be carefully made only within subdisciplinary areas within kinesiology (Knudson, 2019b).

The low number of citations in fields like sport philosophy, sport sociology, and sports coaching, however, does not mean lower scholarly impact. For example, there are numerous, well-cited sport philosophy scholars (e.g., Paul Gaffney, Scott Kretchmar) that do not have a GS Profile or have a GS Profile without these specific subdisciplinary keywords as labels (e.g., Emily Ryall, Sarah Teetzel). In addition, many sport philosophers likely avoid this on logical reasons related to their subdisciplinary expertise (Feenstra, & Lopez-Cozar, 2022). Use of citation metrics in kinesiology should only be interpreted carefully using data within a specific subdiscipline, with database-specific and author-level data (Knudson, 2014, 2015a, 2019b).

Numerous other 'parent" disciplines (e.g., physiology, psychology) and other movement related disciplines (e.g., ergonomics, physical therapy) also publish research relevant to kinesiology. The PR of kinesiology scholars in the top 20 GS profiles in these subdisciplines was normally distributed and indicated a majority (67%) contribution to highly cited research in kinesiology-related subdisciplines. Kinesiology-affiliated scholars were relatively evenly distributed in the top 20 scholars across subdisciplines, so they contributed about equally (64%) to the percentage total citations to these subdisciplines. The current data indicate kinesiology scholars are influential leaders in the scholarly subdisciplines of the field, despite sometimes extensive competition from scholars in other "parent" disciplines or movement-related and professional fields. This indicates greater potential recognition of research by kinesiology scholars than is apparent in use of more general (exercise, kinesiology, sport) GS labels related to the field (Knudson, 2022b). This study also confirmed the inconsistent use of the use of the plural terms of "sport" and "sports" across academe previously reported (Knudson, 2022b; Starosta & Petryuski, 2007). Inconsistent use of terms and keywords can be a barrier to recognition of and the search for kinesiology-related research (Knudson, 2019a, 2022b).

There were several limitations of this study. There is variation and potential bias in scholars who establish GS Profiles and their use of kinesiology-related subdisciplinary keywords as labels for their research interests. There are other kinesiology-related subdisciplines (e.g., performance enhancement, sports law), professional and interdisciplinary areas that were not included in this study. There is also limited data on what scholars create GS Profiles (Kim & Grofman, 2020; Knudson, 2015a, 2015b; Orduna-Malea & Lopez-Cozar, 2017). The substantial number of subdisciplines and skew to citation data limited the data analysis to descriptive observations, however this does not invalidate the trends in scholarly usage of kinesiology subdiscipline research observed in this study that were consistent with previous research on citations in kinesiology (Knudson, 2014; 2015a 2015b, 2022a). Extensive research has documented high skews and uncited articles in most all fields, so focus on top percentiles of cited research is most relevant approach to study usage of scholarly research (Bornmann & Marx, 2014; Leydesdorff & Bornmann, 2011; Leydesdorff & Opthof, 2010; Owlia et al., 2011; Knudson, 2015a, 2015c, 2019b, 2022a; Seglen, 1992; Stern, 1990). The not time-controlled nature of GS, investigator

subjectivity in classifying GS profiles as kinesiology-affiliated, and user profile variation noted above make it impossible to directly replicate this study. Future research could replicate this study in a controlled databases like Scopus, Web of Science, or a conceptual replication/extension (Nosek & Errington, 2020) of this study with GS or other databases like Dimensions.

Conclusion

It was concluded that kinesiology-associated scholars contribute to a majority of highly cited research in most subdisciplinary areas of the field based on keywords used as labels in GS Profiles. Consistent with previous research on citation metrics; there was large variation and skew in citations across twenty subdisciplinary areas of kinesiology and inconsistent use of terms as keywords that may pose a barrier to recognition of and search for kinesiology research.

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A MODEL FOR RETURN TO TRAINING AND COMPETITION DURING ONGOING PANDEMIC CONCERNS

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de la Roche et al. In the wake of a novel Coronavirus, the sports world reeled from the realization that a pandemic of this magnitude had not been seen in more than a century. Reducing the transmission would require physical distancing to such a degree that it would necessitate the suspension of all sporting activities. The multidimensional health effects due to COVID-19 will be far more severe and prolonged if athletes cannot engage in sport at all. Most coaches are concerned with strength and conditioning maintenance as well as technical skill development in response to changes in the sport. Bringing athletes together to train while adhering to government-mandated protective measures, such as facemask use and physical distancing, proved to be a herculean task. The challenge for all sports is how to train in the setting of the new physical distancing required for a healthy community. Sail Canada ran a nine-day training camp and regatta utilizing the knowledge of a team of medical experts to adhere to the government-mandated restrictions without significantly compromising the athletic preparation. The event was a great success and could stand as a model for other sports to maintain training while still protecting the health and wellness of athletes, coaches, and officials.

Key Words: COVID-19, pandemic, coaching, training

The novel coronavirus SARS-CoV-2, which causes the COVID-19 infection, has had a profound effect on all aspects of society worldwide, including sporting events and training. The requirement for physical distancing and mask wearing has rendered athletes in many sports isolated from their ability to train and compete. With myriad competitive and training events having to be cancelled, and facilities being closed due to the global pandemic, coaches were forced to develop creative ways to provide athletes with training opportunities while ensuring they remain healthy in anticipation of future international competition. The substantive matter of interest in this article was the effective operationalization of a sailing event, but the model could be applied to many other outdoor sports. This article was written from a Canadian perspective and so was bound by the local guidelines concerning COVID-19. It is our assumption that several of the strategies employed to control the spread of COVID-19 may have been successful since none of the participants tested positive for the virus up to two weeks following the event. However, the question remains how to continue essential training while adhering to these virus mitigation strategies for many sports.

In response to the government's COVID-19 health restrictions and guidelines, Sail Canada's (the organizing authority for sailing in Canada) coaching staff, recognizing the needs of elite level athletes, organized a training and competition event. Athletes from across Canada, along with the support of their respective coaches, came to train and compete together for the first time in more 15 months. This was as much a trial in how to safely coach in the

setting of COVID-19 as it was a practical exercise to provide training and competition for Canada's top sailing athletes. The nine-day event included four of the nine Olympic sailing events. Men's and women's singlehanded (Laser class for males and Laser Radial class for females) and doublehanded (49er skiff for males and 49erFX skiff females) events ran from August 21-29, 2020, before vaccination was available, such that all participants were therefore unvaccinated. As a pilot project this is more of a descriptive article and many of the protocols explained were designed as issues emerged.

The Contextual Advantage for Sailing

During a pandemic, many sports cannot function because the nature of the specific sport means general physical distancing from other competitors and coaches is not possible. This would include all contact and combative sports and many team sports (soccer, hockey, football, etc.), where there is an inability to control the proximity of one competitor to another, as well as artistic sports that require spotting (figure skating, gymnastics, etc.). Certainly, individual sports can train in isolation, or with a physically distanced coach. However, for many sports the competition must be adapted (staggered starts, etc.) to meet the public health requirements.

Unlike sports such as long-distance running or weightlifting, where training alone can maintain or even improve their performance, the ability to train in technical/tactical/strategic sports like sailing relies on comparison. It is essential to train and compete simultaneously with others to determine what techniques, strategies, and tactics lead to improved performance. Fortunately, within the context of COVID-19, sailing and the associated need for physical distancing is the very nature of the sport. Athletes in double-handed boats must function together in a social bubble (defined later). Also, each athlete must stay in their own boat, which is virtually always going to keep them greater than the 2-meter distance mandated by the safety margins for COVID-19 away from athletes in other boats and/or the coaches. As such, while on the water when either competing or training, the issue of proximity to another athlete or coach is a non-issue. The challenge is incorporating such measures when on land, rigging and de-rigging, as well as pre- and post-race or event debriefs with coaches.

Extensive COVID-19 mitigation strategies were put into place including an emergency action plan in the case that someone did begin to develop symptoms or test positive. No onsite testing was performed. This experience demonstrates that basic public health measures, when applied with consistency and rigor, can result in a safe environment for some sporting events. All participants (athletes, coaches, support staff) were required to sign daily attestation forms, have their temperatures checked, wear a mask, and physically distance while on shore in the boat park, and during launching and returning ashore.

Development of Protocols

To develop the protocols to be instituted a review of the current literature was conducted. Relevant databases related to respiratory disease were identified and searched using the following key words in various combinations: COVID-19, SARS-CoV-2, social/physical distance, mask use, mask compliance, and hand hygiene. Search engines, databases reviewed, and journals cited included the following:

Search Engine Used and Databases Reviewed

Following a rudimentary search using the Google Scholar search engine and its citation index, the following databases were used to secure the requisite articles. Ebscohost, Medline, Pubmed, Biomed Central, PsycInfo, and SPORTDiscus.

Journals Cited

The following journals were cited: Annals of the American Thoracic Society; Disease Modelling; International Journal of Environmental Research and Public Health; Journal of Infection; Infectious Disease Modelling; Infectious, Influenza and Other Respiratory Viruses; Journal of the American Medical Association; Nature Research Scientific Reports; and The Lancet.

Once a list of articles was produced, relevant articles were identified and retrieved from a university library online (including the use of inter-library loan). A reference list was also produced, which includes the article's full citations. The results section will include a critique of selected articles that

highlights key points and draws attention to possible limitations of the article.

Using the information collected and supplemented by information from medical personnel on the front line, a review of current protocols was developed.

1) Given that there is limited empirical data to support the efficacy of various disease mitigation practices, the publication process of peer-reviewed medical journals was used as the criterion for selecting various mitigation practices for review.

2) "Best practices" are examples of successful initiatives to limit the spread of COVID-19; there is no single best practice that universally meets the needs of all programs.

In addition to using this article, practitioners interested in using this as a model for running a similar event, are encouraged to review relevant articles listed in the reference list for further information.

Results of the Literature Review

Support for Mandating Mask-Use, Physical-Distancing, and Hand-Hygiene

The coaching staff, in conjunction with the medical personnel, identified three consistent priorities cited in the literature to help limit the spread of COVID-19. Physical-distancing, hand-hygiene, and mask-wearing were identified as the main measures (Chen, et al. 2020). Facemasks are one of a combination of measures, including physical distancing, hand washing, sufficient ventilation, and the avoidance of crowds and gatherings, that can reduce transmission of COVID-19 (Steinbrook, 2020). Physical distancing along with self-isolation are the most successful protocols to limit the spread of pathogens (Chen et al. 2020; Eikenberry et al. 2020) but these are impractical while trying to train a group of athletes when some level of contact is unavoidable.

Mask-use

Mask-use required the effective use of a mask. Masks are available in a variety of levels of filtering ability (Clapp et al., 2020; Fischer et al., 2020; Howard et al., 2020; Sickbert-Bennett et al., 2020). Cheng et al. (2020b) suggest that the use of facemasks provides a useful and low-cost adjunct to physical distancing and strong hand hygiene. Athletes, officials and administrators had to shift their focus from self-protection to altruism where facemask use becomes a symbol of solidarity in response to the pandemic.

Clark at al. (2020) described the unique challenge for coaches and to ensure adequate cooperation and compliance amongst participants. The athletes, officials, and administrators had to be persuaded of the importance of compliance. The medical team and the coaches highlighted their belief in the efficacy of healthy behaviors to promote compliance by modelling the health behavior recommendations. Although practicing health behavior recommendations is important within the current pandemic, it may also be useful as a starting point for developing appropriate health behaviors within the group for other public health concerns faced by athletes (e.g., annual flu season, long-distance travel, etc.).

Our observations contribute to the literature on the implementation of protocols calling for physical distancing, and face mask usage from a behavioral perspective. Specifically, we study the effect of masking on physical distancing with a combination of a field evaluation by medical experts and a complementing attestation (see Appendix B). An additional concern expressed by Seres et al. (2021) was to ensure that participants do not reduce other crucial precautions like physical distancing. The medical personnel determined that the most effective way to support adequate masking was to provide masks onsite on an as-needed basis. Although (K)N95 masks would have been the optimal choice, due to availability issues, American Society for Testing and Materials (ASTM) level 1 surgical masks were selected.

Physical Distancing

We prefer this term over "social distancing" because it clearly defines the parameters of the restriction rather than alluding to a limit on social interaction although that is curtailed to some extent by limiting handshaking, hugging, and kissing which are important greetings in many cultures. Physical distancing was eminently possible for all participants in this event and required no specific supplies. Chen et al. (2020) notes that keeping physically distant is problematic where children are involved. For children

to consistently conform to new rules requires focused supervision and reinforcement. Fortunately, at this particular event children were not present, but many sports have significantly younger participants.

For the purposes of this study physical distancing was evaluated by observation. This was exacerbated by an inability for the observers to determine when athletes were in the same social bubble. Bubble identifiers in the form of a color coded garment of some sort would have aided in identifying failures in physical distancing.

Social Bubble. For the purposes of this event, it seemed prudent to define social bubbles and provide a rationale. A social bubble refers to a small, clearly defined group of people that agree to limit their social contacts to only those within the bubble which should be no larger than ten. Social bubbles would include roommates, sailing partners, training partners, and possibly coaches. Included in the social bubble, would be everyone living in the same dwelling, using the same bathroom and kitchen facilities. Creating new social bubbles during this event allowed competitors in the same boat, who are not in the same family, to have the requisite close contact when rooming together, and dining together, and while sailing together without face masks.

All coaches and athletes had to acknowledge that they were part of a bubble and agree to minimize close social contact with people outside of the bubble. People within the bubble were permitted to interact with one another without physical distancing or mask wearing although good hand hygiene was always encouraged. It is important to get agreement from everyone that they will join the social bubble and recognize the restrictions that are entailed in joining. That means they agree to join only one social bubble, and physically distance with anyone outside their social bubble.

Social bubbles also allowed for more rapid contact tracing in the event of a case of COVID-19 within a social bubble and would include anyone that had come into close contact with members of that social bubble.

Another component of physical distancing, which was initiated by the coaches and athletes, was to stagger the location of the boats within the boat park, rather than lined up like cars in a parking lot. This provided a three-meter distance between boats during rigging, derigging, and maintenance.

Hand Hygiene

Frequent hand washing is cited as the primary weapon in the fight against the transmission of COVID-19 (Howard et al., 2020; Seres et al., 2021; Steinbrook, 2020), however, we use “hand-hygiene” as an all-inclusive term also used in the literature (Chen et al., 2020; Cheng et al., 2020a) to include handwashing with soap and water, and/or the use of various chemical hand sanitizers or wipes. As a rule, hand hygiene takes place in the privacy of a washroom or using a pocket bottle of sanitizer. It was not reasonable to attempt to measure hand hygiene simply by the number of times someone accessed the public hand sanitizer. Instead, the use of reminder signage and accessible stations was the extent to which hand hygiene was included. Seres et al. (2021) also recommend proper coughing and sneezing etiquette which is also hard to assess due to its random occurrence.

Efficacy of Facemask Use

Face coverings such as masks have become a major source of prevention in the spread of COVID-19. (Cheng et al. 2020a; Clark et al. 2020) There has been considerable recent research addressing some of the issues on how COVID-19 is spread, whether it is airborne or droplet based, and what types of face coverings are most effective. (Fisher et al., 2020; Sickbert-Bennet et al., 2020). The general consensus at time of writing is that COVID-19 is spread primarily by droplet or micro-droplets which can travel multiple meters following an unobstructed cough or sneeze or even loud speaking or singing (Asadi et al. 2020a). There is also evidence that particles in the form of fomites, which can survive for extended periods of time on surfaces may subsequently be spread by touch. However, this is probably less common (Kanamori, 2020).

COVID-19 has energized a stream of research on the efficacy and compliance of facemask use to prevent the spread of the virus. Before mandating mask use, it was important to peruse the research literature to determine if there was adequate support for mandating that athletes make such a departure from their normal routine.

> Airborne transmission of infectious respiratory diseases involves the emission of microorganism-containing aerosols and droplets during various expiratory activities (e.g., breathing, talking, coughing, and sneezing). Transmission of viruses in emitted droplets and aerosols to susceptible individuals may occur via physical contact after deposition on surfaces, reaerosolization after deposition, direct deposition of emitted droplets on mucosal surfaces (e.g., mouth, eyes), or direct inhalation of virus-laden aerosols (Asadi et al. 2020b, p. 1).

Liu & Zhang (2020) support the use of facemasks to reduce transmission of a virus when individuals must interact with one another and are not within the same social bubble.

> The face mask that one person wears to reduce the potential release of droplets that contain virus complements the mask that another person wears to reduce the risk of inhaling these droplets. The consistent, correct, and universal wearing of face masks increases the benefit for individuals, and for all. This is neither rocket science nor a political statement. It is common sense and responsible behavior (Steinbrook, 2020 p. 470).

There had been concern voiced in the media, and by the public, that exercising while wearing a facemask could reduce available oxygen by trapping air thus preventing adequate carbon dioxide exchange. Hopkins et al. (2020) found mask wearing to "have small and often difficult-to-detect effects on [the work of breathing], blood gases and other physiological parameters during physical activity, even with heavy/maximal exercise" (p. 405). Although not required, if an athlete chose to wear a facemask, while on the water, during training and/or competition, there is no indication that it would impair performance.

The term facemask has come to represent a wide range of devices that could potentially be used to reduce aerosol transmission. There is also a wide range of commercially produced personal protective equipment (PPE) that could be used by athletes during training and competition, but due to the limited supply and higher demand it was difficult to specify specific PPE. Significant variability in the efficacy of face coverings has also been demonstrated in the literature (Fischer et al. 2020) which support either medical face masks or multiple ply (two layers or greater) close knit cloth masks.

Hopkins et al. (2020) noted that a variety of options were available from tight-fitting industrial and healthcare standard respirators, which would be inappropriate for sport use, to surgical masks, homemade or store-bought fabric masks, and loose-fitting bandanas or neck gaiters. Steinbrook (2020) concluded that a folded cotton bandana had approximately a 50% filtration efficiency and that improved fit between the mask and the wearer's face increased filtration efficiency, such as through use of an aluminum nose bridge. The medical team deemed it prudent to investigate alternative options.

There is also debate about who the mask is protecting. Pre-COVD-19, in non-health related settings, such as industrial applications, the use of facemasks have focused on protecting the wearer from aerosol and particulate inhalation, so the emphasis was the protection of the wearer. "The most common application in modern medicine is to provide protection to the wearer (e.g., first responders), but surgical facemasks were originally introduced to protect surrounding persons from the wearer" (Fischer et al. 2020, p. 1).

The prevailing sentiment amongst the medical personnel on-site was that mask wearing was required to protect the athletes from one another and the coaching staff, any of whom may be carrying the virus yet be asymptomatic at the time. Cheng et al. (2020b) suggest that the emphasis needs to change to one of the wearers protecting others from respiratory droplets due to the potential for infection before symptoms are obvious or from asymptomatic carriers of the virus. They also note the opportunity to carry out research on compliance during a pandemic was not possible previously. Clapp et al. (2020) confirm that facemasks must completely cover the nose and mouth to be an effective intervention for preventing transmission of the virus. Appropriate fitting and usage of facemasks was a critical component of the assessment.

Assessing the level of compliance through observation was easiest for mask use compliance. A

simple glance around the venue would quickly determine the number of noncompliant individuals.

Additional Benefits of Facemask Use

There has been concern voiced that compulsory facemask use emphasizes potentially counterproductive effects from incorrect use and a false sense of security. The improper use of masks can be mitigated with training. The argument that facemasks give individuals a false sense of security is dispelled by Betsch et al. (2020), Cheng et al. (2020b), Clapp et al. (2020), Howard et al. (2020) and Seres et al. (2021). Howard et al. (2020) confirm that handwashing combined with universal mask wearing reduces the spread of respiratory viruses but noted a significant secondary benefit being the visual reminder to others of the pandemic to increase compliance with unspoken social pressure. Seres et al. (2021) "show that individuals keep a significantly larger distance from someone wearing a face mask than from an unmasked person" (p. 139) which is aided by "a potential bias toward socially desirable behaviors" (p. 141).

Wearing a mask is a form of social contract which provides motivation to group members who would otherwise be noncompliant. Betsch et al. (2020) noted "compliant people perceive each other more positively, and noncompliance is socially punished" (p. 21852). Mask wearing by everyone involved was critical to the success of the event and high levels of compliance by all those involved in the training and competition would be of particular importance for the protection of coaches and administrators present (Cheng et al., 2020b; Clapp et al., 2020). Betsch et al. (2020) based their results on self-reported data whereas our results were grounded in real-life observations. Simply put, "masks help people keep their droplets to themselves" (Howard et al., 2020, p. 2).

Equipment Contamination Concerns

Concern was expressed regarding equipment contamination from an asymptomatic athlete or coach. Ratnesar-Shumate et al. (2020) determined that; "Ninety percent of infectious virus was inactivated every 6.8 minutes in simulated saliva and every 14.3 minutes in culture media when exposed to simulated sunlight representative of the summer solstice at 40°N latitude at sea level on a clear day" (p. 214). The medical team was satisfied that the likelihood of the virus surviving on equipment for any meaningful portion of time was minimal. Considering equipment is almost entirely synthetic material (fiberglass, stainless steel, anodized aluminum, various plastics, nylon, dacron, and mylar) and any wood components are coated in several layers of polyurethane, boats and equipment are unlikely to serve as significant fomites.

Coaching staff worked closely with the local Public Health Unit, municipality and, the sport's COVID-19 Medical Task Force to ensure everything was done to make the event as safe and successful as possible during these challenging times. The literature review supported the COVID-19 restrictions and guided the event organizers' implementation of the protocols.

The Event

The intent of the event was to create an elite level racing environment to focus on honing and maintaining racing skills for Olympic aspirants as a replacement for attending international competitions during a time when was it was not possible due to international travel restrictions. This case-study was to assess the efficacy of virus mitigation strategies to maintain training of elite athletes and avoid complete cessation of their programs. Coaches noted this was critical at the elite level both from a skill maintenance perspective and for mental health and stress reduction.

COVID-19 Constraints

Considering the research conducted, and to comply with local, regional, and provincial health authorities, the coaches, on-site at the event, developed several criteria that had to be met within the boat park and during the event, which included:

i) Masks to be worn at all times when on land by all participants, coaches, and staff.

ii) 2-meter social distancing to be maintained at all times by those, not in a specific "bubble" (i.e., a crew of 2 for a two-person boat).

iii) Daily attestation confirming no COVID-19 symptoms (see Appendix B).

iv) Daily temperature checks of all participants, coaches, and staff.

v) On-site washroom facilities.

vi) On-site hand sanitizing stations.

vii) A separation of 3 meters between boats when they were being rigged and de-rigged or during the launch/recovery process.

viii) No “visitors” in the boat park.

ix) An on-site source of drinking water.

x) Regatta staff stay on-site whenever training/racing was underway and during rigging and de-rigging.

xi) Controlled entry and egress to the boat park.

xii) No "rafting together" on the water (i.e., boats could not come alongside one another between races/exercises, which included coach boats).

xiii) Briefing and de-briefing was conducted via Zoom meetings as were protests.

xiv) Any individual or coach who became symptomatic during the event had to withdraw and not come to the site until cleared of COVID-19 as would any member of their social bubble.

xv) Any person with a positive COVID-19 test had to withdraw permanently as well as all members of their social bubble.

Despite these restrictions and precautions, there was considerable interest from a large number of athletes and coaches to participate in this event.

Athletes travelled from across Canada to attend this event although the majority were from central Canada. Few athletes travelled by aircraft, some chose to travel by automobile from afar to minimize the risk of contracting disease associated with travelling.

The Setting

The setting for the event was held at a venue built specifically for Olympic sailing events due to its water and wind characteristics, making it a favorable place to sail and compete. The site has a grassy area which was roped off to the public and housed 28 single handed sailboats and 16 double handed sailboats. The area reserved for the single-handed boats was 20 by 55 meters (1,100 square meters) and the area for the double-handed boats was 18 by 25 meters (450 square meters) which was ample space to store the boats overnight and then move them in the morning so that there was always a minimum of three meters between boats to ensure that the two-meter physical distancing between athletes and coaches could be maintained during the rigging process. The launch site was 60 meters from the controlled area. Volunteers, wearing protective gloves and masks, were on hand to assist with launching and the return to shore after each day of sailing to avoid athletes having to help each other launch and retrieve the boats.

In all, there was a maximum of 60 athletes on-site at any one time as well as up to 10 coaches and a further 10 – 15 staff/volunteers (officials, audit staff, support personnel, administrators, etc.) for a total of up to 85 people. Ages ranged from 15 to 65, with the majority being between ages 15 and 25.

The nine-day event schedule was set in such a way that the doublehanded athletes competed on days one through four and days six through nine. The female singlehanded athletes competed on days one through four, while the male singlehanded athletes competed on days six through nine. Day five was reserved as a recovery day for the doublehanded sailors and a transition day from female to male for the singlehanded sailors. This schedule ensured that there were never more than 46 competitors in the boat park area at any given time.

The female singlehanded athletes completed twelve races and male singlehanded athletes completed fifteen races over four days. Both male and female doublehanded athletes completed twenty-four races over eight days.

We found that a hands-on approach with on-site volunteers providing constructive reminders, equipped with spare masks and available to answer questions was both practical and impactful. Such considerations would be important in replicating these results.

The protocol and controlled environment were limited to the sailing venue. We did not control what the athletes were doing after sailing with respect to living arrangements, restaurants, or evening outings. Athletes were provided guidelines and the Kingston area regional Public Health Authority had been proactive in providing clear guidance to restaurant owners and hotels that would have been visited by the sailors. This is very much in accordance with the real-life scenarios of any amateur event.

Audit Measures

To monitor behavior, and ensure compliance, audits were performed daily on an audit form (see

Appendix A) examining several metrics which included:

i) PPE and hand sanitizer supplies

ii) Attestation (Appendix B) and daily temperature checks (touchless thermometer)

iii) Daily attendance record to permit contact-tracing if required

iv) Bathroom facilities

v) Compliance with mask-wearing

vi) Compliance with physical distancing

vii) Compliance with boat distancing

Metrics v, vi and vii were collected whenever the athletes and coaches were onshore in the controlled area. The audit process was applied randomly to ensure ongoing compliance and ranged between 15 and 30-minute intervals. The process was modeled after the infection prevention and control processes used in most hospitals and other healthcare settings in Canada when auditing compliance of healthcare workers with PPE utilization (mask use and hand hygiene). Audits of physical resources such as bathroom facilities, hand sanitizing stations, potable water for the athletes, and security were done daily at the beginning of each day.

Data Collection

Auditors were on site daily and were not affiliated with the regatta management nor the administrative process. All auditors had to abide by the same COVID-19 screening protocols as the athletes, coaches, and regatta/training personnel. In all there were 2,567 separate observations that were documented using the audit tool to determine compliance over the entire nine days of the event (see Appendix A).

Athlete compliance was measured both within the boat park as well as during the transition stage from boat park to the launch ramp, when launching in the morning and the reverse in the evening during the return to shore. Compliance was also measured during the rigging of the boats when increased space (three meters) was required between boats to enable the athletes to safely walk around their boats without violating the two-meter rule with an athlete rigging an adjacent boat.

Outcomes

The two key performance metrics to ensure the safety of the athletes which were monitored were the wearing of masks and physical distancing.

Mask Use

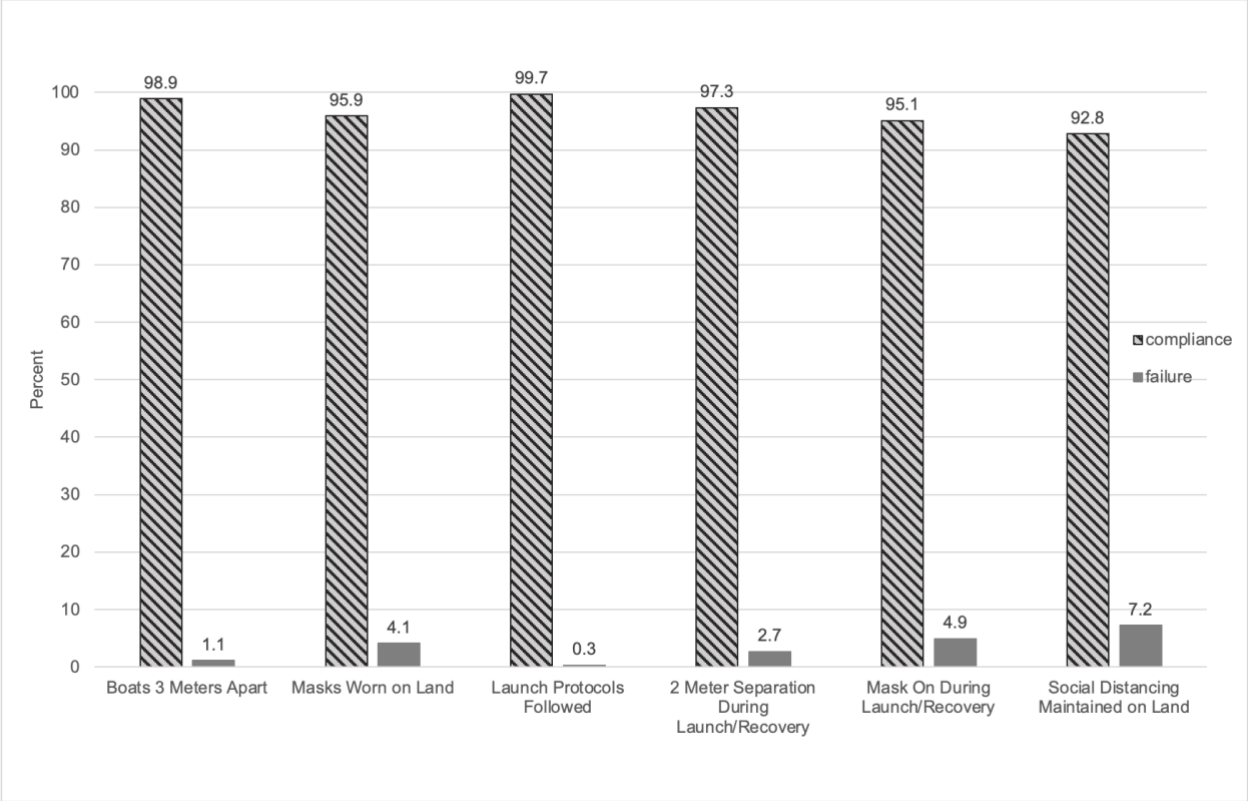
The supplied ASTM level 1 surgical masks were mandatory for all athletes, coaches, staff, and auditors when on land and specifically in the boat park. Wearing of masks on the water is not advisable. The wet environment reduces the efficacy of the mask and possibly creates a safety concern. Athletes need to transition out of wearing masks before entering the water and organizers provided reusable sealed plastic bags to athletes to help protect the mask properties during the sporting activity. These racing craft do not provide dry spaces, so the athletes had to retrieve their masks as they transitioned back to land at the end of the day's competition while handling their boats on the ramp. A failure in mask use was documented when either a mask was not worn or worn improperly (i.e., the nose and/or mouth were exposed). Furthermore, on occasion when some athletes decided to supplant the provided surgical masks with other single layer face coverings (such as buffs or bandanas) was also deemed a failure as the efficacy of these in droplet control has been recently questioned by several researchers (Asadi et al. 2020b; Clapp et al. 2020; Fischer et al. 2020; Sickbert-Bennett et al. 2020). In each case of a failure being recorded the athlete was also provided corrective advice. Compliance for the wearing of a mask was found to be exceptionally high when in the boat park and only slightly lower during the transition phases to and from the launch area (see Figure 1).

Physical Distancing

Physical distancing was defined as being two meters away from the next closest person except when with someone from a person's own "bubble". Bubbles were usually either two athletes sailing in the same boat plus their coach or a single athlete in the case of a single person boat such as the Laser and that athlete's coach. For the most part, physical distancing was maintained in the boat park during the rigging and de-rigging process and during launch and recovery (see Figure 1).

Figure 1

Compliance with COVID-19 Protocols Days 1–9.



Discussion

While mask wearing compliance within the public varies between a low of 40 percent and a high of 60 percent, we found the athletes to be highly motivated and demonstrated compliance rates of 95.9% on land and 95.1% during launch and recovery. It is not surprising that the compliance during launch and recovery was lower as it was not infrequent that a sailor would land and find that his or her mask was wet or damaged or forget to put it on immediately upon stepping ashore. This was ultimately partially resolved by having a volunteer at the water's edge with a supply of masks to provide one to any athlete who landed without a mask, or with a damaged or soiled mask. Based on discussions with both athletes and coaches we attribute the high compliance with mask wearing, at a level that rivaled that seen in the health care settings, to the motivation of the athletes by their coaches as well as the presence of auditors on site. Success here could open the opportunities for future similar events.

Physical distancing was also maintained at a high level, again due in part to the presence of an audit team and vigilance on the part of the coaches. It is worth noting that the physical distancing during launch and recovery was superior to that in the boat park itself (97.3% versus 92.1%). It is postulated that this was a in part a function of the mechanics of launching of only one or two boats at a time with the space needed to physically launch a boat on the launch ramp as well as the absence of any "socializing" during this phase of the process. A secondary cause for a perceived lower compliance with social distancing in the boat park was the difficulty in accurately identifying "social bubbles" by the auditors since they were unfamiliar with the athletes, coaches, and teams from the same club. It was not infrequent that a violation was identified when in fact the third person may have been a coach or other team member from the same "bubble". This could be alleviated in future by having all team members from a single bubble wear some article of

clothing (i.e., a "bib") of the same colour such that it would be easier to readily identify individual "bubbles" and violations from a distance. In this study, the number of violations of social distancing was likely over-stated when the athletes were in the boat park.

One and Two-week follow-up

Every athlete, and coach was contacted at the seven- and fourteen-day interval following the event to determine if there had been any need to test for COVID-19 based on symptoms. In all, 60 athletes and 10 coaches were contacted as well as the support staff who participated. At day seven, three individuals underwent COVID-19 testing of which one person was symptomatic and two were asymptomatic and tested for other reasons (employment, travel etc.). All three tested negative and a non-COVID-19 diagnosis was assigned to the one individual who had symptoms. By day 14, three more individuals had been tested. All were asymptomatic and all three also had negative COVID-19 swabs.

Conclusion

This experience demonstrated that it is possible and safe to operate training and a competitive regatta in the setting of COVID-19. We recommend that masks be worn at all times by all athletes, coaches, and support staff and that physical distancing of two meters is maintained. The use of "bubble identifiers" would aid greatly in monitoring physical distancing for the on-land component. We found excellent compliance the daily self-reporting and attestation form completion and with all virus mitigation measures including hand hygiene with this motivated group of high-performance athletes. It is our hope that this event may be used as a template to assist in running safe training and competitive events during the COVID-19 pandemic and beyond. Outdoor sports such as many winter alpine events (skiing and other sliding sports), cross-country skiing etc. and summer events like rowing, canoe/kayak, etc. could use this template to plan and execute training and competitions in a safe yet functional manner ensuring Olympic athletes maintain their training and competition readiness while simultaneously beginning the preparation and mentorship of the next generation of Olympic athletes. A thorough debrief of the event has been done with the organizing staff and the two medical officers who were on site. Any conclusion here should be made in consideration of the timing of this event, the prevalence of COVID-19 at the time of the event both locally in Kingston Ontario and in Canada during the month of August 2020.

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A COMPARISON OF HEALTH LOCUS OF CONTROL AND PHYSICAL ACTIVITY AMONG SEVENTH-DAY ADVENTISTS AND NON-SEVENTH-DAY ADVENTISTS

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Feiler & Ngo. This study aimed to assess the correlation between physical activity (PA) levels and health locus of control (HLOC: internal, external-chance, external-powerful others, God/God locus of health control) among Seventh-day Adventists (SDA) and non-SDAs. The sample of this study included 185 individuals aged 22 to 81 who were employed by or attending an SDA affiliated higher education institution during the 2020-2021 academic school year. By completing the survey voluntarily, the participants provided their PA level and information regarding their HLOC. To analyze the impact of HLOC on PA, a multiple regression analysis was conducted. While overall results for a majority of respondents showed high levels of PA, SDAs reported statistically significant lower PA than did non-SDAs. HLOC (internal, external-chance, external-powerful others, God/God locus of health control) was not a significant predictor for PA.

Key Words: Seventh-day Adventist, physical activity, health locus of control, God locus of health control.

Introduction

Physical inactivity has become the world's fourth leading cause of death (World Health Organization [WHO], 2019). This lack of physical activity (PA) contributes to multiple chronic health problems, such as high blood pressure, heart disease, diabetes, weak bones and muscles, poor weight management, and even some cancers (WHO, 2019). Within the United States, almost 80% of adults do not achieve enough PA (Centers for Disease Control and Prevention [CDC], 2017), which has resulted in annual healthcare costs of about $90 billion (Carlson et al., 2015). Even though the CDC (2017) recommends adults obtain 150 minutes per week of aerobic exercise and 2 days per week of muscular strengthening exercise, the average American adult has a difficult time following such recommendations.

Much research has been done on PA within selected groups of individuals, including those who are part of religious groups. With more than 92% of Americans identifying with a religion, it is important to question if there is something there that contributes to PA engagement, or lack thereof (Pew Research Center, 2020). Unfortunately, religiously-connected people tend to get significantly less PA than the recommendations (Ahrenfeldt et al., 2018; Aljayyousi et al., 2019; Banerjee et al., 2017; Geller et al., 2019; Joseph et al., 2017; Lycett, 2015; Nathenson & Wen, 2013; Park et al., 2018; Pullins et al., 2018; Rabiepoor et al., 2019; Thomson et al., 2015; Tristão Parra et al., 2018; Waters et al., 2018; Williams et al., 2016). However, there is one group that appears to contradict these findings: Seventh-day Adventists (SDAs).

SDAs are Protestant Christians who are distinguished by the belief in the second coming of Jesus Christ and the observance of the Sabbath – the

seventh day of the week in the Hebrew calendar (General Conference of SDAs (Seventh-day Adventists) [GC], 2019). The SDA belief system encourages the practice of healthy lifestyles, including a diet that is mainly plant-based and avoids animal products that are deemed to be "unclean" according to the Bible, regular PA, resting on Sabbath (Saturdays), worshiping, and engaging in social fellowship (GC, n.d.). One SDA hub is Loma Linda, CA, and has been labeled a "Blue Zone," which is one of the areas around the world where people live the longest and healthiest lives (Buettner, 2010). Loma Linda is home to a flagship SDA medical school and hospital; the Loma Linda residents' secrets for longevity were daily engagement in regular PA and belonging to a faith-based community where there is support for practicing the lifestyle recommendations of the SDA church (Buettner, 2010). Hence, there is a known correlation between PA and the health beliefs of those within the SDA faith. In Lindsted et al.'s (1991) longitudinal study of SDA men, they found that moderate levels of PA protected them from all causes of death, thereby delaying death to 95.6 years, as compared to the national average of 78.8 years (CDC, 2018). Acosta Enríquez et al. (2019) examined lifestyle behaviors of SDA and non-SDA adolescents and found no differences in PA levels, although those who participated in a sport had low body mass index levels. Koenig's (2012) systematic review found that religiously-involved people exhibited a mostly positive relationship to obtaining adequate PA. There are many factors that influence PA and health beliefs; one such factor is health locus of control (HLOC).

HLOC refers to the position one takes in controlling one's decisions for their own health. According to Wallston (Wallston et al., 1978; n.d., 1993, 2005), the three subcategories for HLOC are internal, external-chance, and external-powerful others. Internal HLOC indicates that health is in one's own control. External-chance HLOC indicates that one believes their health is controlled by fate or luck. External-powerful others HLOC indicates that one believes their health is controlled by significant others, such as doctors, and/or God or individuals with a higher power. Wallston et al. (1999) expanded the HLOC category of external-powerful others and developed the God locus of health control (GLHC). This aimed to better understand how belief in God played a role in health control – how much does a person believe that God controls their health?

How HLOC shapes preventive health behavior, such as PA, has previously been studied in multiple population groups. Sak et al.'s (2013) study of college students' health behaviors showed primarily internal HLOC with additional significant influence from external-powerful others. Similarly, Bennett et al. (2017) found that college students who used online and/or application health trackers were likely to have high HLOC scores for both internal and external-powerful others. Helmer et al. (2012) and Carlson and Petti (1989) all found young adult students with high internal HLOC had high PA, whereas those with high external-chance HLOC had low PA. Rongen et al. (2014) discovered that employees with high internal HLOC were likely to have high self-rated health yet low engagement in employee wellness programs. Anastasiou et al. (2015) found that adults with high internal HLOC were more likely than those with high external HLOCs to engage in adequate PA. Webb et al.'s (2012) study found that pregnant women were less likely to participate in PA if they had high external-chance HLOC scores. Moshki et al. (2014) found postpartum depressive women showed decreased external and increased internal HLOCs after four months of depression intervention. Thomas et al. (2016) determined that African American women had higher internal HLOC and increased PA at a 6-month follow-up of an intervention to improve lifestyle choices. Pudrovska's (2015) longitudinal study found that as compared to men, women had more PA limitations and lower self-rated health, yet higher religiosity – which was associated with high internal HLOC.

Regarding GLHC and PA, Robinson and Wicks (2012) found African American women showed high GLHC and low levels of PA. Karvinen and Carr (2013) determined that GLHC scores were negatively associated with PA and internal HLOC, yet positively associated with both external HLOCs. Boyd and Wilcox (2020) discovered that college students who frequently attended religious services were likely to have high GLHC and external HLOC scores, and low internal HLOC scores.

It is important to note that no publications to date have addressed the combination of HLOC (internal, external-chance, external-powerful others, GLHC)

and PA in a religiously-affiliated population. This study investigated the relationships between the independent variables (IV) of HLOC's internal, external-chance, external-powerful others, and GLHC categories, and the dependent variable (DV) of PA. The null hypothesis stated that HLOC subscales would not significantly predict PA.

Methods

For this study, four pre-existing questionnaires were combined into one survey that was administered via email using PsychData: (1) International Physical activity (PA) Questionnaire (2002), which measures PA during leisure time, at work, and for transport within the last week, and has been reliably and validly correlated with accelerometer data (Kim et al., 2013; Macfarlane et al., 2011; Papathanasiou et al., 2009); based on Cohen's guidelines a medium effect size (0.39) was found for total PA (Kim et al., 2013), good test-retest reliability and Spearman's correlation for total PA (r = 0.35; Macfarlane et al., 2011), and intra-class correlation coefficients were high for total PA (0.84; Papathanasiou et al., 2009). Next, (2) the Multidimensional Health Locus of Control (Wallston et al., 1976) measures an individual's level of belief regarding control factors over their health as internal, external-chance, and external-powerful others, and has shown to have moderate reliability with Cronbach alphas ranging from .60 - .75, and test-retest stability coefficients from .60 - .70 (Otto et al., 2011; Wallston, 1993). Then, (3) the God Locus of Health Control (GLHC; Wallston et al., 1999), which measures an individual's level of belief that God is in control of their health, has shown strong alpha reliability at about .90 and has validly measured religious beliefs about health (r = .29 and .32, between GLHC scores and religious importance ratings, and r = .42 and .47, between GLHC and using religion to cope with pain; Mills et al., 2018; Murray et al., 2006; Robinson & Wicks, 2012; Wallston, 2005; Wallston et al., 1999). Last, (4) Short Form 36, which measures self-reported health-related quality of life (RAND Corporation, 2019), has shown to have established validity and reliability above 0.80 (Ware et al., 1993), and median relative precision at 0.93 (McHorney et al., 1992, 1994). None of the pre-existing questionnaires included demographic questions; such questions were added in and included age, gender, ethnicity, education level, marital status, household number, and religious affiliation. This article will focus on results from the first three questionnaires and the demographic element of religious affiliation.

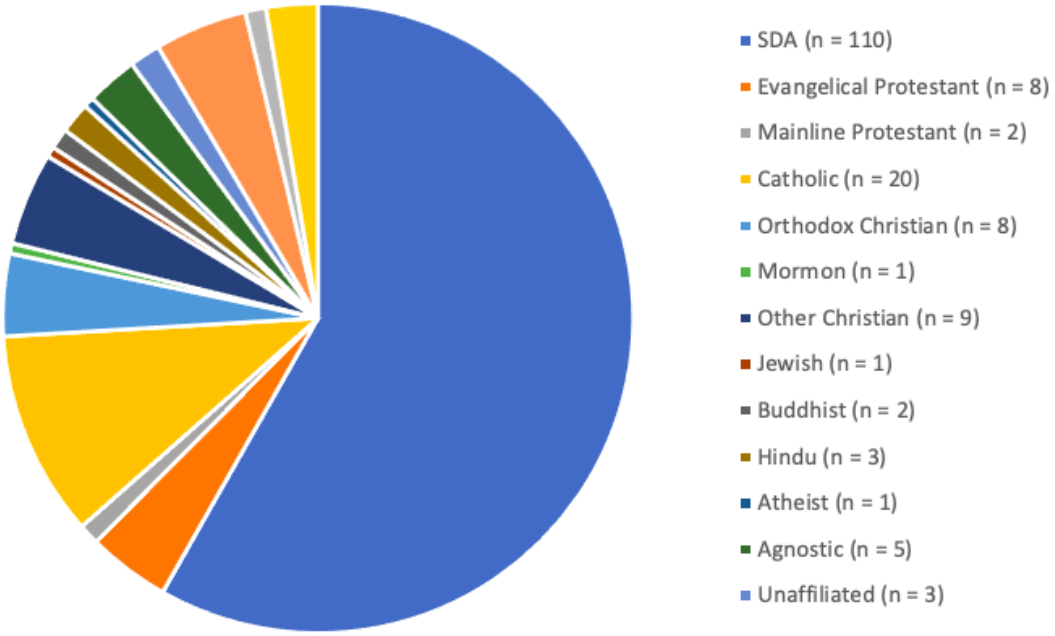
From February through April 2021, the survey link was sent once to all individuals with active institutional email addresses at three SDA-affiliated higher education institutions, as the minimum number of respondents was met with a single email at each institution. These individuals were employed by or attending an SDA-affiliated higher education institution during the 2020-2021 academic school year. The respondents were informed about their voluntary participation and their right to withdraw from the study at any time. SPSS version 27 was used to analyze the data.

Results

A total of 313 initiated the survey but only 185 students, faculty, and staff from three SDA-affiliated institutions completed the self-response survey. Age of participants ranged from 22 to 81 years of age, 68% identified as female, and 59.5%% identified as SDA (see Figure 1). After collection, the data was analyzed using descriptive and inferential statistics. Multiple regression was conducted to examine the relationship between HLOC (internal, external-chance, external-powerful others, God/GLHC) and the self-reported PA levels among participants. The novel coronavirus SARS-CoV-2, which causes the COVID-19 infection, has had a profound effect on all aspects of society worldwide, including sporting events and training.

Figure 1

Religious Affiliation



The regression showed that the model was not statistically significant ($F(4, 165) = .329$, $p = .858$, $R2 = .008$) and the null hypothesis was not rejected. The independent variables included in the model were not significant predictors of PA, meaning that no HLOC category had a significant impact on PA levels (see Table 1). However, the results showed that 66% of the participants reported high levels of PA (achieving at least 3,000 METS per week), 28% reported moderate levels of PA (at least 600 METS per week), and 5% reported low amounts of PA (less than 600 METS per week; see Table 2).

Table 1

Regression Analysis Results

Research Question	IV	β	r_s	p	R^2
					.008
DV: PA					
	Internal	.044	.296	.596	
	External - Chance	.044	.613	.627	
	External - Powerful Others	.045	.773	.597	
	God/GLHC	.022	.604	.795	

Table 2

PA Categories for Different Age Groups (Percentages Shown for Total of All Respondents)

Age (in years)	Low	Moderate	High
22-29	4 (2.3%)	19 (11.1%)	52 (30.4%)
30-39	2 (1.2%)	9 (5.3%)	30 (17.5%)
40-49	2 (1.2%)	8 (4.7%)	9 (5.3%)
50-59	0 (0%)	8 (4.7%)	17 (9.9%)
60-69	0 (0%)	3 (1.8%)	4 (2.3%)
70-79	1 (0.6%)	1 (0.6%)	1 (0.6%)
80+	0 (0%)	1 (0.6%)	0 (0%)

Note. Table total percentage = 100%.

In comparing SDAs and non-SDAs, the results showed some differences. When compared to non-SDAs, SDA's had significantly higher internal HLOC scores ($t(182) = 2.251$, $p = 0.026$, $d = .338$), which was a small effect. There were no significant differences between SDAs and non-SDAs for any other HLOC category (external-chance: ($t(183) = -1.865$, $p = .064$, $d = -.279$; external-powerful others: ($t(183) = -2.274$, $p = .024$, $d = -.341$; GLHC: ($t(183) = -0.70$, $p = .944$, $d = -.010$).

More than 60% of SDAs achieved a high amount of PA, while 75% of non-SDAs had a high amount (see Table 3). For moderate amounts of PA, 33% of SDAs whereas 22% of non-SDAs obtained moderate amounts. Almost 7% of SDAs and just under 3% of non-SDAs had a low amount of PA. SDAs had statistically significantly lower PA levels than did non-SDAs ($t(169) = -2.883$, $p = 0.005$, $d = -.479$), which was a moderate effect.

Table 3

PA for SDAs and Non-SDAs

	Low PA	Moderate PA	High PA
SDAs	7%	33%	60%
Non-SDAs	3%	22%	75%

Discussion

The results from this study showed that none of the HLOC subscales was a statistically significant predictor of PA, therefore we failed to reject the null. This finding is not consistent with previous studies which found a positive relationship between high internal HLOC and high PA levels, and a negative relationship between external-chance and/or external-powerful others and PA (Anastasiou et al., 2015; Carlson & Petti, 1989; Helmer et al., 2012; Karvinen & Carr, 2013; Rongen et al., 2014). In addition, the present study's findings do not align with research that has shown those with high GLHC scores were less likely to engage in PA in any amount (Karvinen & Carr, 2013; Robinson & Wicks, 2012). These differences comparing past studies with the present study are addressed below.

In comparing HLOC of SDAs and non-SDAs, SDAs had higher internal scores, which indicates that they believe they have greatest control over their own health and health outcomes. This is not to say non-SDAs do not have high internal HLOC scores, simply that SDAs scored even higher. The high internal HLOC score for SDAs could be associated with the SDA belief that God empowers individuals to be in control of their lives, rather than leave things to chance, fate, or other influences. There were no other differences between SDAs and non-SDAs in the other categories for HLOC (external-chance, external-powerful others, God/GLHC). Although not part of this study, attendance at religious services has shown to be positively correlated to high GLHC scores (Boyd &

Wilcox, 2020). This is an element that could be addressed in future studies.

The finding that more than half of participants engaged in moderate or high levels of PA was surprising yet consistent with Lindsted et al.'s (1991) study on SDAs. Koenig (2012) and Park et al. (2018) had each previously found that religious involvement and PA were positively correlated, although Acosta Enriquez et al. (2019) found no differences in PA levels when comparing religious and non-religious individuals. This study's findings are a stark contrast to CDC (2017) reports that have indicated about 80% do not get enough PA. In addition, many other studies have shown that religiously-affiliated individuals do not obtain adequate PA (Aljayyousi et al., 2019; Banerjee et al., 2017; Geller et al., 2019; Joseph et al., 2017; McKenzie et al., 2015; Nathenson & Wen, 2013; Rabiepoor et al., 2019; Thomson et al., 2015; Tristão Parra et al., 2018; Waters et al., 2018; Williams et al., 2016). It is likely that the PA of this study's sample is more greatly influenced by other, non-HLOC factors that were not part of this study, such as access to PA locations (indoor, outdoor), familial support, and previous positive PA experience, among other potential factors. One possible explanation might be related to the COVID-19 pandemic – Cheval et al. (2021) found that many individuals increased their leisure-time PA during shutdown, as compared to pre-pandemic levels, which showed to help reduce the negative impact of the stressful time on mental health.

It should be noted that while all respondents worked at or attended an SDA institution, most respondents (59.5%) identified as SDA and most of the remaining respondents identified with a different religion. Only 10.8% combined identified as either agnostic, atheist, unaffiliated, nothing in particular, or did not wish to respond – which could mean many things. With about 90% identifying with a religion, this is similar to the Pew Research Center's (2020) previous finding that 92% of Americans identify as religiously-affiliated.

This study had a few limitations, including the failure to draw causal relationships between the investigated variables and the use of a self-report PA measurement tool, which is less accurate than accelerometers and can allow respondents to overestimate their actual PA (Downs et al., 2014; LeBlanc & Janssen, 2010; Troiano et al., 2007). With this in mind, PA levels in this study may have been lower than reported. In addition, there may have been other, non-HLOC, factors that influenced PA participation for this study's participants, including time spent caring for family members or at work; physical limitations or illnesses; both religious and PA attitudes, beliefs, behaviors, and/or practices that were not investigated within this study; and the COVID-19 pandemic, which impacted health and the workplace, which required many people to work from home, and thereby changed the work-home dynamic and related physical and mental health. Specific religious factors for future studies could include religious service attendance, prayer, and views on the role of God/a higher power and sanctity of the human body.

Nevertheless, most of the participants in this study reportedly achieved high levels of PA and only 5% of the participants obtained insufficient PA. These findings contradicted previous studies which showed that many people of a religiously-affiliated group, such as SDAs, tend to not engage in adequate PA (Aljayyousi et al., 2019; Banerjee et al., 2017; Geller et al., 2019; Joseph et al., 2017; McKenzie et al., 2015; Nathenson & Wen, 2013; Rabiepoor et al., 2019; Thomson et al., 2015; Tristão Parra et al., 2018; Waters et al., 2018; Williams et al., 2016).

Conclusions

This study was conducted to examine the impact that HLOC (internal, external-chance, external-powerful others, God/GLHC) has on PA among those working at or attending SDA institutions of higher education. Although previous research found a positive correlation between HLOC and PA, the results from this study indicated that none of the HLOC subcategories is a significant indicator of PA. This suggests that other factors play a stronger role in influencing the high PA levels of the sample in this study, such as time spent caring for others, illness, religious beliefs, and PA beliefs, among others. Further research should be conducted to assess the relationship between HLOC and PA among SDAs when the settings of the study are not influenced by COVID-19, as well as using a non-subjective PA measurement tool, such as accelerometers.

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EXPLORING LEARNING OUTCOMES AMONG UNDERGRADUATE KINESIOLOGY STUDENTS IN RESPONSE TO AN INCLUSIVE PHYSICAL ACTIVITY PROMOTION MESSAGE ASSIGNMENT

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Ross & Thomas. Numerous professional bodies and curricular models in kinesiology call for the development of undergraduates' cultural competency. In short, a culturally competent professional (a) mitigates personal biases from adversely affecting others, and (b) is aware of how societal patterns marginalize people (e.g., unquestioned norms; Gill, 2007). The present study aimed to evaluate the extent to which undergraduate students demonstrated learning in response to completing an inclusive physical activity promotion message assignment, which included a focus on designing materials inclusive of people with disabilities. A scholarship of teaching and learning approach was adopted to critically evaluate and reflect on an assignment used in an undergraduate kinesiology course. This case study drew on artifacts from a convenience sample of 10 undergraduate students enrolled in an introduction to adapted physical activity course. A descriptive discourse analysis was conducted of students' reflections about what they learned from the assignment. Student responses were appraised with Fink's (2013) taxonomy of significant learning for evidence of learning across six domains: i.e., foundational knowledge, application, integration, human dimension, caring, and self-determination. Student responses were coded and verified. Consensus was reached on all discrepancies. Student reflections signaled learning across four domains: foundational knowledge (n = 9), application (n = 3), integration (n = 5), and human dimensions (n = 6). Developments in the caring or self-determination domains were not evident. The findings indicate potential for the assignment to enhance Kinesiology curricula. As teacher-researchers, we discuss the findings in relation to further development of the assignment to better promote cultural competency.

Key Words: coaching and physical education teacher education (PETE), disability, exercise science, equity, workforce training

Kinesiology, as an academic discipline, is called upon to prepare undergraduate students to be agents of positive change through the promotion of health and well-being for all (Cervantes & Clark, 2020; Gill, 2007; James, 2021). Kinesiology undergraduate majors often pursue careers in fitness and sport education or allied-health fields (Nuzzo, 2020; Thomas, 2014). Whatever the career, students will likely serve a diverse clientele, including individuals with disabilities, or will need to expand access to the services they provide on the field or in the clinic (Elshahat et al., 2021; Keadle et al., 2021; Kennedy et al., 2021). To make headway in increasing equity and accessibility of services and environments, kinesiology educators seek to develop students' cultural competency, as well as technical knowledge and skillsets. A "culturally competent professional acts to empower participants and challenge

restrictive social structures" (Gill, 2007, p. 283), and has (a) awareness of how their own values and biases impact their clients'/students'/athletes' experiences, and (b) the knowledge and skills to create inclusive atmospheres (Robey et al., 2013). In recognition of its importance, the American Kinesiology Association (AKA; Chodzko-Zajko et al., 2018) and the Society of Health and Physical Educators, America (SHAPE America, 2017) both identify cultural competency as a core element of undergraduate preparation in kinesiology and physical education.

Towards that end, the present study developed and evaluated an undergraduate course assignment targeting physical activity (PA) messages and messaging for a diverse clientele, specifically individuals with disabilities. Messages represent what is communicated (e.g., messages focused on motivating, advising, or informing), whereas messaging is the physical or technological conduit used to disseminate messages (Brawley & Latimer, 2007). End-users simultaneously interphase with messages and messaging whenever they access mediated forms of communication, such as print- or web-based PA promotion material (e.g., print brochures, webpages; Thomas 2019). Future and current professionals should be aware of the need to ensure quality promotional messages and messaging and be equipped to do so (Love et al., 2021; Smith & Thomas, 2020). On a regular basis, the public seeks and accesses PA-related promotion material in diverse ways, including through the websites of government agencies, professional organizations, private providers, non-profit organizations, and/or university-based centers (Clarke et al., 2016; Prestin et al., 2015; Vallance et al., 2008). To be effective, the design of messages and messaging (i.e., promotion material) should be culturally responsive to the diverse ways of obtaining, processing, and understanding information (Natkunam et al., 2020; Ross & Ross, 2021). Yet, large-scale evaluations of PA and health-related digital messaging have revealed materials that are largely inaccessible for diverse populations due to unsuitable required reading grade levels (Thomas et al., 2018), non-compliance with disability access standards for digital media, including issues with font style, content layout, and lack of alternative text for images (Shaw 2017; Visser et al., 2021; Disability Rights Commission, 2004), and poor or missing representation of persons with disabilities (Bruning et al. 2020; Comella et al., 2019; Mitchell et al., 2019).

Kinesiology professionals are well-positioned to promote health and well-being for all through websites and other digital media associated with fitness and health clinics, sport programming, etc. (McManus, 2022). Thus, intentional educational efforts to prepare professionals to apply techniques for health literacy promotion and recognize the value of this practice in support of health equity, is needed (May et al., 2022; Visser et al., 2021). Despite this call to action, there has been limited improvement over the past quarter century in the accessibility of health promotion materials (Cardinal & Sachs, 1992; Thomas et al., 2018; Thomas & Cardinal, 2020). Notably, improved translation of health knowledge and skill to consumers is observed when techniques for health literacy assurance are used (e.g., teach back, readable material; Kiser et al., 2011; Sheridan et al., 2011), warranting further efforts to improve the effectiveness of health communication disseminated by diverse professionals (Smith et al., 2022; Smith et al., in press). Failure to address this gap impedes realization of the Healthy People 2030 goal to increase the health literacy of the population (Health Communication/Health Information Technology Research Objective 1; US Department of Health and Human Services [USDHHS], n.d.). Thus, more explicit educational efforts to prepare emerging professionals to be proficient in digital, text-based health communication is needed.

To address this curricular gap in preparing kinesiology undergraduates in health literacy promotion (Thomas et al., 2021a; Thomas et al., 2021b), we developed a lesson plan for one undergraduate introductory course on adapted PA. Broadly, our goal was to increase awareness and practical skills around accessible and disability inclusive PA promotional material (Ross et al., in press). This study focused on the inclusivity of individuals with disabilities, while recognizing that culturally competent professionals demonstrate appreciation for diversity across gender, age, race/ethnicity, religion, ability, and other intersections of identity (AKA competency #81, Chodzko-Zajko et al., 2018). Individuals with disabilities are largely underrepresented within

health-related messaging (Visser et al., 2021), including web-based sport and PA promotion (Hardin et al., 2001; Martinez-Bello, 2017) and programming (Comella et al., 2019). To effectively design disability inclusive PA materials, kinesiology professionals need to recognize this current issue of underrepresentation and its historical/cultural impact on participation and health among individuals with disabilities (AKA competency #7 & 9, Chodzko-Zajko et al., 2018).

Through this article, we critically evaluate and reflect on our development and implementation of one course assignment to promote cultural competency among kinesiology undergraduates. The lecture and activities related to our assignment aimed to prepare kinesiology pre-professionals with strategies to design disability inclusive PA promotional material using digital platforms. Principally, we designed our assignment to address this through instruction and activities focused on three issues which limit the usefulness of digital PA promotional material: readability, accessibility, and inclusivity. This research was guided by the question: could an assignment evaluating and creating PA messages inclusive to people with disabilities raise awareness among kinesiology undergraduate students of how design decisions may affect the reach and impact of digital PA promotional materials (AKA competency #7, Chodzko-Zajko et al., 2018)? We anticipated that the assignment would help students identify and question their own assumptions about people with disabilities' engagement with PA promotional material. Moreover, we anticipated the assignment would help students identify techniques to improve the accessibility and inclusivity of PA promotional material, guiding ethical decisions in future professional roles (AKA competency #8, Chodzko-Zajko et al., 2018).

Methods

A Scholarship of Teaching and Learning paradigm (SoTL; Trigwell et al., 2000; Guillory & McLaughlin, 2018) was employed to critically evaluate and reflect on the extent to which the assignment facilitated development of cultural competencies (Liston & Rahimi, 2017). We situated ourselves as teacher-researchers, engaging in reflective pedagogy (Bailey, 2012) to advance our effectiveness as educators, and make "transparent how we have made learning possible" (Trigwell, 2000, p. 156). This research was delimited to appraising the educational effectiveness of one assignment for the purpose of a course evaluation; the research was not done to generalize findings to any specific population or context. As such, this study was acknowledged by the first author's institutional review board and deemed exempt as an evaluation of standard teaching practices.

Participants and Study Setting

A convenience sample of undergraduate students enrolled in an introductory adapted PA course, for which the first author was the instructor, were included in the present case study (Atkinson, 2012). The required course serves the physical education curriculum and kinesiology as an introduction to teaching/coaching in an adapted PA environment. The study setting was a large public university located in the southeast region of the United States (CollegeData.com, n.d.). The purpose of this course is to give students developmental knowledge, an authentic teaching environment, and content knowledge for a variety of disabilities. The course was delivered in the Spring 2021 semester and 100% online, using a synchronous and remote instruction format, due to the COVID-19 crisis (Taylor et al., 2021).

Sixteen coaching education majors of sophomore and junior standing were enrolled and eligible for inclusion in the study. Six students did not complete the assignment, or they submitted incorrect documentation, resulting in an inclusion rate of 62.5%. The deidentified work submitted by the students was the primary unit of analysis for this study, which was conducted post-semester. Given the nature of the research, student consent was waived.

Assignment Description

Communication is a primary route to promote PA and a prevailing culture supportive of active living as a means to health and a quality life (Sallis et al., 2006). Given that websites and other digital media are primary routes in which adults seek health advice and to improve their health literacy (Prestin et al., 2015), our assignment focused on media-based communication. When considering media-based PA

communication, there are two parts to keep in mind: messaging and message (Brawley & Latimer, 2007). Messaging is the physical medium used to communicate a message (e.g., webpage, print flyer). The message, in comparison, is the substance of the communication (e.g., appeals, factual statements, advice; Brawley & Latimer, 2007). The suitability of media-based PA materials for a wide audience can be represented by reading grade level, compliance with disability accessibility standards, and representation of diverse communities.

The assignment was added to an introductory course on adapted PA to raise awareness of persistent issues in PA promotional material, and the ways these issues intersect with the social experience of disability, namely barriers in fully accessing PA promotion material and services provided to clients or the public (Thomas et al., 2022a; Ross et al., in press). The assignment was introduced during the third week of the semester within a unit on federal legislation and inclusion frameworks as they apply to PA participation among individuals with disabilities. The related instruction, class activities, and homework encompassed one 7-day period. To our knowledge, this was the students' first introduction to digital health promotion messaging within the program curriculum, and it was assumed students had not had prior experience with the course content.

The assignment was originally developed by the first author, an expert in adapted PA, and implemented in a course section one year prior to this study. The second author, an expert in readability and accessible PA messaging, was invited to support development of the assignment for use in future course sections. The original assignment was revised based on both authors' experiential teaching knowledge and an extensive review of the literature. An example assignment can be found in Appendix A and includes a summary of background literature used to inform the assignment lesson plan. The specific learning objectives for our course assignment, and ways they align with national standards for kinesiology undergraduate curricula, are reported in Table 1. The assignment included two components. First, for the in-class component, student groups were tasked with evaluating an example PA promotional message that could be used for a fitness organization or school's website and social media campaign. The in-class task included a lecture overview of issues and guidelines. Student groups evaluated example promotional messages using a checklist of best-practice guidelines for (a) reading grade level (Thomas et al., 2021b) (b) accessibility (Education and Outreach Working Group [EOWG], 2016; Henry & Dick, 2018), and (c) disability inclusion (Kraus & Jans, 2014). Guideline checklists used within the assignment were curated by the first author based on best-practice recommendations (see Appendix A).

Table 1

Learning Objectives and Alignments

Course level objectives	**Aligned kinesiology curriculum standards**
Assignment purpose: • Develop professional knowledge and technical skills to effectively promote physical activity through written/text-based messaging for diverse clientele/population. **Learning outcomes:** • Evaluate PA promotion messaging for accessibility and inclusion, as it relates to readability and clients with disabilities. • Create health promotion messages using guidelines for accessibility and inclusion, including	**Kinesiology core curriculum elements** (AKA[1]; Chodzko-Zajko et al., 2018) Cultural, historical and philosophical dimensions of physical activity *A kinesiology graduate will be able to* • (#7) Describe the sociocultural and historical factors that influence physical activity. • (#8) Demonstrate an appreciation of cultural diversity and make ethical decisions.

using plain language, ADA compliant formatting, and inclusive, respectful terminology.

Aligned course learning outcomes:

- Recognize and understand current issues related to participation of unique populations in sport.

- (#9) Critically evaluate scholarly work related to cultural, historical, and philosophical dimensions of physical activity.

SHAPE[2] America standards (2017)

- (#6a) Engage in behavior that reflects professional ethics, practice and cultural competence
    - Teaches using culturally sensitive approaches
    - Creates classroom atmosphere that is inclusive
    - Demonstrate equitable treatment for all students

Note. This assignment investigated in the present study was initially developed for delivery in the Introduction to Adapted Physical Activity course, within the Physical Education and Kinesiology Bachelor of Science Degree Program at West Virginia University (United States).
[1]AKA means, "American Kinesiology Association." [2]SHAPE means, "Society of Health and Physical Educators."

Second, for the take-home component of the assignment, students individually engaged with educational materials (e.g., videos, website articles) related to digital literacy levels in the US, federal laws around digital accessibility (e.g., Section 508 of the Rehabilitation Act of 1973, The Plain Language Act of 2010), and frameworks for designing materials inclusive of people with disabilities (e.g., "Commit to Inclusion" national campaign). Appendix A includes these supplemental resources and a full reference list provided to the students. As part of the homework component, students individually revised the example PA promotional messages to comply with best-practice guidelines shared through the assignment.

Finally, students were prompted to reflect on their learning following the completion of the homework component. Two open-ended questions were used: (a) "What did you learn from this activity? and (b) In what ways could you use the tools for effective communication introduced in this activity in your future career or personal life?" Students submitted their completed assignments, including their revised promotional message and personal reflection, the following week in class.

Theoretical Assumptions

Cultural competency is conceptualized as a set of attitudes and practices which ensures services are perceived as respectful to end-users; they ensure services are designed in ways that encourage end-users to fully engage in a program or service offered by an organization (Campinha-Bacote, 2002). Cultivating skills in cultural competency can raise awareness of assumptions or biases that are held by a person designing services or programs (Gill, 2007). Theoretically, cultural competency encourages an end-user centered approach to understand how clients or members of the public may perceive components of a service or program (Robey et al., 2013), which may affect their motivation to participate or engage. Moreover, cultural competency is fostered through reflecting on how the beliefs and values that one has as a provider may differ from those held by end-users (Campinha-Bacote, 2002), which in the case of kinesiology professionals may be clients, athletes, students, or the general public. Robey and colleagues (2013) showed, in their literature review, multiple studies where providers held large misconceptions about what patients with disabilities would attribute as their daily activities and quality of life. Such a divide between health providers and end-users could adversely affect efforts by providers to design

material and services which are responsive to patient values, life constraints, and health-related priorities (Robey et al., 2013). Concerning PA promotion, this translates into absent or limited initiative to become educated on barriers faced by end-users with disabilities, as well as an absent or limited ability to design accessible and inclusive promotion services and programs (Campinha-Bacote, 2002).

Our course assignment, evaluated in the present study, was structured to teach undergraduate kinesiology students about how cultural competency specific to persons with disabilities overlaps with skills in designing readable promotional material for the public (Thomas et al., 2022b; Ross et al., in press). Activities of the assignment not only taught students about perspectives for inclusive material design (e.g., representation; Bruning et al., 2020), but also for accessible design (e.g., perceptible content; Ross et al., in press). Accordingly, completing the course assignment was theorized to instill in students an awareness of routine (i.e., normative) practices which impede PA promotion material from being inclusive and accessible for individuals with disabilities (Ross & Ross, 2021). Moreover, it was anticipated the assignment would raise student awareness that cultural competency is a process and an ability (e.g., tasks could elicit students to reflect on their readiness to design effective PA promotional material).

Analytic Plan

Discourse analysis

A discourse analysis was performed of the semantics used by students in their written reflections on learning to determine which, if any, types of significant learning were experienced (Barnes & Caprino, 2016; McMullen, 2021). The domains from Fink's taxonomy of significant learning (2013) were used to code and discuss student reflections: i.e., (a) foundational knowledge, (b) application, (c) integration, (d) human dimension, (e) caring, and (f) self-determination. Student reflections could be coded for more than one domain (e.g., one statement corresponds with foundational knowledge and another with human dimension). As we were interested in the ways which the assignment may have elicited significant learning, if at all, we made the *apriori* decision to quantify the number of student submissions representative of each domain of significant learning (i.e., an interpretive content analytic approach was used; Armat et al., 2018; Elliot & Timulak, 2021). Cultural competency may be observed as self-knowledge, self-awareness, or transformation of one's way of knowing, or empathetic interest in how one's actions (or lack thereof) impacts people and environments (Cervantes & Clark, 2020). As Fink's taxonomy operationalizes learning beyond cognition, including ethics, integrity, aspirations, continued interest in a topic, and self-awareness (Fallahi & LaMonaca, 2009), it was deemed an appropriate framework for facilitating the discourse analysis for the course assignment in the present study (Elliot & Timulak, 2021).

Confirmability and rigor

The first author independently identified and coded statements within the student reflections for representation of significant learning. Adjacent to each code for significant learning, the first author included annotation explicating her rationale on why the statement was representative of the identified domain of significant learning. After the first author's independent coding, the second author served as a 'critical friend' (Thomas et al., 2022b); he reviewed the first author's coding and interpretations for any (dis)agreement with the first author (Lee & Yoon 2020). This delineation of reviewer roles was determined prior to data coding and analysis. As the primary instructor of the course, the first author sought a 'critical friend' to lend an outsider perspective and challenge interpretations (to reduce bias). In qualitative inquiries, 'critical friends' enhance rigor by "encourage[ing] exploration of multiple and alternative explanations and interpretations as themes [are conceptualized] in relation to the data" (Smith & McGannon, 2018, p.113; also see Brulé, 2020). Coding agreements were counted and reported as an indicator of trustworthiness (Thomas et al., 2022b).

Results

The first author's preliminary review identified evidence within student reflections for significant learning in the domains of (a) foundational knowledge (8 of 10 students), (b) integration (1 of 10

students), and (c) human dimension (8 of 10 students). The second author, as a 'critical friend', agreed with 18 of 30 coded statements across the 10 student reflections (60%), and identified five additional representative statements. Disagreements primarily challenged the first authors' conceptualization of Fink's application versus integration versus human dimension domains. Through reflexive and iterative dialogue, the first and second authors contextualized Fink's domains to the assignment and reached consensus on all discrepancies. Broadly, we further contextualized the three domains in the following way: (a) application was evidenced by the student projecting how they would extend the topics or skills studied through the assignment to alternative tasks, professional roles, or settings; (b) integration was evidenced by the student projecting how their learning would help them to perform a different professional role better, to appreciate an approach, or to envision how the quality of service/care they provide would impact others; and the (c) human dimension was evidenced by the student projecting personalized goals or their 'ideal self' following a sense of achieving self-awareness or self-discovery (one driver towards learning in this dimension could be an expanded sense of empathy due to a new experience or realization) (Fink, 2013).

Consensus discussions between the authors identified a total of 35 statements within the 10 student reflections demonstrating significant learning. Employment of the 'critical friend' (second author) enriched the interpretations of the data. Overall, student reflections signaled that cultural competency was promoted across four learning domains: foundational knowledge (n = 9), human dimension (n = 6), integration (n = 5), and application (n = 3). Table 2 presents example reflection statements from students, the corresponding assigned learning domain, and consensus interpretations.

Table 2

Sample Coding of Student Reflection Statements

Representative statements from student reflections	***Fink's domain of significant learning.*** **Consensus interpretation**
"I purposely cut down on syllables and used simpler words just so it'll be easier to understand."	*Foundational Knowledge*. Student recalls key concepts related to reducing reading grade-level to improve suitability of PA promotion content for a diverse lay audience.
"In my opinion some things just need to be said in more complex ways. In the case of an inclusive sports training program offered by a fitness gym sure, but if it is a college advertising an elite level showcase camp in which scholarships will be rewarded, a more complex form of advertisement is necessary"	*Application.* Student demonstrates critical thought for how ideas learned may apply in a different context, and what factors might influence that, such as audience or marketing goals.
"I was surprised to see that millions of Americans cannot read above a 5th grade level. In the future, when addressing a large group of people, I want to make sure that I use inclusive language, and I want to make sure that the readability is not confusing in any way and is comfortable for most."	*Human Dimension:* Student was "surprised", suggesting reflective thought and consideration of self and others. Student projects ideal self in saying "I want to do this" and demonstrates an understanding of how they can interact more effectively with others.

Discussion

As teacher-researchers, we critically evaluated the extent to which an undergraduate assignment, tasking students to evaluate and revise digital PA promotional messages inclusive of people with disabilities, could develop students' cultural competency. Cultural competency includes knowledge in how the design of programs or services may affect end-user perception of such resources and their motivation to engage with them (Campinha-Bacote, 2002). The assignment extended this consideration to the very messages used to promote PA programs or services (Thomas et al., 2022a). Accordingly, the present study's research question focused on if students became aware of how the design of PA promotional messages affected their reach and impact, specifically as it relates to health literacy and disability inclusion. Using Fink's taxonomy of significant learning (2013) to analyze students' reflections about their learning, we identified ways the assignment could develop students' cultural competency.

Foundational Knowledge

The findings suggest cultural competency was primarily developed through gains in foundational knowledge. When asked what they learned, most students focused on techniques to improve readability and accessibility of digital materials. Students centered their comments on how the first message drafts were not ready for lay communication. Limitations often cited by students related to the use of jargon, polysyllable words, and long sentences. Students also expressed importance in adding alternative text descriptions to graphics and using a clear layout design. It seems the assignment's focus on accessibility helped students become cognizant of design issues which impede the ability to perceive content, primarily as it relates to experiences of individuals with visual impairments. It is possible that prior to the class, students were unaware of ways typology and spacing affects how content is read under certain conditions (e.g., intellectual/visual disability, using a screen reader software; Bureau of Internet Accessibility [BOIA], 2019).

According to Fink's taxonomy, students deemed this knowledge gap as significant. This suggests the assignment could help students recall and understand design issues which limit the reach of PA promotional messages to the disability community (Visser et al., 2021). This potential aligns with several disability-related cultural competencies at the program, university and academic field levels (see table 1). Most notability is the potential to increase students' awareness of how disability (and literacy) affect interactions with health material from the viewpoint of end-users with disabilities. The study results also align with competencies to be aware of, and support, alternate forms of communication (Robey et al., 2013).

Human Dimension

Just over half of the students' responses corresponded to the human dimension domain of Fink's taxonomy. The findings suggest the assignment could elicit students to make realizations about themselves or others (Fink, 2013). Several students specifically wrote that they were surprised most Americans often require health-related material to be written at/below an eighth-grade reading level (Han & Carayannopoulos, 2020). Meeting this cut-point would ensure adults have comfortable reading experience with text-based promotional material, as well as a lowered risk of mis-comprehending material content (Center for Disease Control and Prevention [CDC], 2022; Warde et al., 2018). One student even remarked that they had never considered how a person who is blind engages with digital content. Beyond informing the student that impaired vision (e.g., blindness) occurs along a continuum (American Foundation for the Blind, n.d.), the experience of revising the example messages helped the student understand how content is perceived/heard using assistive technology (BOIA, 2019). Moreover, statistics provided about literacy and disability potentially helped several students realize their own assumptions concerning the quality of PA promotional messages and who can(cannot) access them. Students who conveyed a personal realization often expressed appreciation for how applying the techniques they learned improved the revised message.

Learning within the human dimension domain relates to cultural competencies focused on practice settings (Robey et al., 2013). The self-awareness fostered through the assignment could encourage students to recognize how their own attitudes, values, and practices affect the ability of people with disability to access health-related information and services (Robey et al., 2013). In the present study, however, students did not devote substantial articulation to any personal biases they held towards people with disabilities, which the assignment may have brought to light (Robey et al., 2013).

Integration

Results specific to the integration domain suggests the assignment may positively shape professional identity (Trede et al., 2012). The integration domain deals with anticipating ways a current experience can inform one's future work (i.e., future role or career; Fink 2013). Beyond listing the tools which they would use in the future, this subset of students also declared the tools would ensure they were equitable in promoting PA (e.g., presenting messages inclusive of everyone, readable to all, understood by everyone). They specifically spoke of personally communicating with clients or the public, which were not limited to text-based content but inclusive of verbal communication too (e.g., when talking with clients). From a cultural competency perspective, this suggests the assignment could support students in being concerned that the material they produce are consistently accessible, acceptable, and doable (Robey et al., 2013). These results further show how the assignment could foster attitudes aligned with SHAPE Standard 6a, which is to promote inclusivity and equitable treatment through one's professional practice. Similarly, it aligns with AKA competency #8 around demonstrating appreciation for cultural diversity and making ethical decisions in practice (Chodzko-Zajko et al., 2018). These referenced standards in kinesiology align with the cultural competency to understand the values and belief systems of end-users (Robey et al., 2013), namely in what end-users would like to see prioritized in the health-related material or service that they access (Elshahat et al., 2021; Natkunam et al., 2020). Our results suggest the assignment may help students recognize digital communications are accessed by a diverse population of end-users.

Assignment Efficacy

The suggested efficacy of the present assignment could be better understood in relation to previous research. First, learners are generally unaware of health literacy barriers, regardless of their employment experience, program stage, or area of study (Saunders et al., 2019). An array of student appraisal activities seems to successfully reinforce lessons taught through didactic instruction or assigned media (Saunders et al., 2019). Many studies lack a control-group or a pre-/post-test analytic design (Saunders et al., 2019), which makes qualitative research even more important. When assessing student learning, a frequent response to open-ended questionnaires from students appears to be increased awareness (Beyer & Thomson, 2016). This includes precise ways to write in plain language at appropriate reading grade levels. Our main finding, that most responses aligned with foundational knowledge, is consistent with previous qualitative research. Second, scenario-based activities may elicit a newfound sense of professional responsibility (Chen et al., 2013), helping to explain why both the integration domain and human dimension domain were top areas of significant learning within our sample. Learners may often comment on not suspecting the health material they locate or create as barriers to health promotion. Previous studies suggest teaching multi-modal ways to promote health literacy may be helpful (Chen et al., 2013). Our activity centered on access by persons with disabilities, while other studies included tools to verbally assess health literacy or critique material with established coding forms (Chen et al., 2013). As observed in this study, didactic instruction paired with scenario-based application exercises may primarily elicit learning in three domains of Fink's taxonomy: foundational knowledge, integration, and human dimension.

Future Development

The present findings provide insight into ways the assignment could be further developed. First, zero student statements corresponded with the caring domain of Fink's taxonomy. Gill (2007) characterized

culturally competent professionals as individuals empowered to "challenge restrictive social structures" (p. 283), which requires a genuine interest in understanding or addressing larger societal issues. In our sample, students did not comment on ways to solve systemic issues surrounding inequitable access to health information. Future iterations of the assignment may seek to elucidate this issue for students or explore contributing factors proximal to themselves. We might anticipate learning in the caring domain to be demonstrated by students' concern or frustration with systemic forms of bias, or an expressed desire to advocate for change (Cardinal, 2016; James, 2021). More explicit scaffolding may stimulate reflective thinking and significant learning across this additional domain of Fink's taxonomy (Coulson & Harvey, 2013). Towards that end, we revised the post-assignment reflection prompts, and trialed them in subsequent course sections taught by the first author. The original and revised prompts are detailed in Table 3. Questions eliciting reflection in the caring domain prompt students to consider their reactions to the inaccessibility and non-inclusivity of the example message presented for the assignment, as well as the reaction or feelings of an end-user with a disability.

Table 3

Reflection Question Prompts

Original Assignment	**Fink's Domain Targeted**
What did you learn from this activity? In what ways could you use the tools for effective communication introduced in this activity in your future career or personal life?	These were not written with Fink's taxonomy in mind. The findings of the present study suggest these original prompts may elicit statements which align with several domains.
Revised Assignment	**Fink's Domain Targeted**
[Now in use]. What was your reaction (feelings, or thoughts) to this assignment?	Caring domain (may also target human dimension domain)
[Now in use]. What did you learn from this activity? In your answer, use terminology and concepts introduced in this activity and provide specific examples/observations.	Foundational knowledge (may also target human dimension domain)
[Now in use]. Think about a person with a disability who might encounter your promotional message. How would their experience differ if they were presented with your first draft compared to your revised draft of the example message?	Caring domain (may also target human dimension)
[Now in use]. In what ways might the inaccessibility and non-inclusiveness of physical activity promotion messages impact people with disabilities?	Foundational knowledge domain (may also target caring domain)
[Now in use]. In what ways could you use what you have learned in this assignment in your personal and professional life?	Integration domain (may also target application domain)

[Planned for future use]. What challenges did you have in completing your revised PA promotional messages? Explain your response.	Application domain (may also target human dimension domain)
[Planned for future use]. What strategies did you use (or could you use) to overcome the challenges presented above if encountered in the future? Explain your response.	Application domain (may also target human dimension domain)

Note: [1]The domains of Fink's taxonomy are not conceptualized as mutually exclusive or sequential, but rather represent developmental processes supporting continued and integrative learning which learners recognized as relevant to their lives (Fallahi & LaMonaca, 2009; Fink 2013).

Additional considerations for future development are the absence, or minimal presence, of student statements aligned with the self-determination and application domains, respectively. Chen et al. (2013) reported students discovered creative solutions to rewriting material at target reading levels, such as by replacing blocks of text with graphics or bullet-point lists. Future iterations of the assignment may elicit problem solving through innovative thinking. Tasking students to meet a greater array of guidelines or precise benchmarks could help (e.g., to write at two reading grade levels: 8th and 5th grade). Moreover, prompting students to seek out resources and examples on their own may empower life-long learners (i.e., self-determination). Similar effects may be achieved by tasking students to revise or create real-world material, in addition to mock material, for programs they are personally connected to (Chen et al., 2013).

Study Limitations and Future Research

There are limitations to the present study, which should guide the interpretation of its results and the direction of future research. First, the present study was delimited to one course at one university and is not generalizable to broader student populations. Moreover, there was potential for omission bias, wherein students may have experienced learning across Fink's domains in ways not reflected in their written work. We sought to address this limitation through more targeted reflection questions in subsequent iterations of the assignment (Table 3). Concerning the caring domain, we now ask students to imagine the experience that persons with disabilities might have after encountering both versions of the example promotional message (i.e., the initial draft and their revised version). Concerning the integration domain, we revised the question on future use to focus on how students could use what they have learned in their personal or professional lives, rather than which tool they would use. This change may elicit broader contemplation of ways the lessons taught are relevant to students' future endeavors, inclusive of concepts, prevalence data, tools, and techniques. Finally, we plan to add two additional prompts for reflection to a future iteration of the assignment, which focus on (a) any challenges students may have experienced with revising the PA promotional messages and (b) any strategies they used to address them. Qualitative research suggests that such prompts may capture learning within the application domain of learning (Chen et al., 2013).

Beyond expanding the reflection prompts used, future efforts could also probe for learning through interviews or the examination of additional student artifacts (McNamara & Haegele, 2021). In support of this step, we have planned additional evaluations for our assignment, including examining the extent to which the students' revised promotional messages complied (and improved adherence) with inclusivity and accessibility standards (i.e., additional measure of foundational knowledge and skill mastery were added).

A second limitation of the present study was using reflection questions on the experience of revising promotional PA messages as a proxy measure of cultural competency. Future efforts to capture students' development in specific cultural competency areas is needed. This may include the adaption of questionnaires designed to measure

precise dimensions of cultural competency (Robey et al., 2013). Such questionnaires could elicit students to contemplate personal biases towards a population group, as well as describe factors beyond disability that complicates service access and utilization (Robey et al., 2013). Moreover, evidenced learning specific to cultural competency would entail expressing an understanding of what a population segment values about PA and what they prioritize in promoting it for themselves or those they care for (Robey et al, 2013). A direct measure of cultural competency may ask students to consider the future, anticipate issues they may face, and identify ways they may mitigate these challenges. Notably, this latter measure may capture learning within the self-determination domain of Fink's taxonomy.

Finally, limited research in kinesiology appears to focus on the objectives of the present study, despite a clear need to (Bruning et al., 2020; Thomas et al., 2021b). A 2019 systematic review contained no publications within kinesiology focused journals (Saunders et al., 2019). Moreover, future research using experimental study designs with pre-post follow-up questions is needed (Saunders et al., 2019). The inclusion of our assignment along with both iterations of our reflection questions should support future experimental research (see Table 3 and Appendix A; for further example, see Kamp & Thomas, 2022).

Conclusion

As teacher-researchers, we responded to the call for reflective pedagogy (Bailey, 2012) and made transparent our process of assignment development and evaluation (Trigwell et al., 2000). Evidence for learning across four of Fink's (2013) six domains demonstrate the course assignments' potential for developing kinesiology undergraduates' cultural competency. The apparent gaps we observed in learning within the caring domain and self-determination domain, as well as the minimal learning evidenced within the integration and application domains, inform ways to further develop assignments like the one investigated in the present study.

Footnotes

We use the term competency in reference to the specific core educational standards proposed by the AKA, but the reader should be aware they are called, "core elements," within the source article. Terminology in reference to these core elements may vary, such as when they are adopted as specific course learning objectives or program learning outcomes.

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Appendix A

Note: As mentioned within the Methods section, this appendix presents the lesson plan (i.e., in-class activity) and homework (i.e., outside of class activity) delivered to students; this appendix contains the full reference list provided to students, and all references presented in this appendix also appear in the Reference section of the companion article.

SUBJECT: Kinesiology

POTENTIAL COURSES: Adapted physical education/activity, Sport for exceptional athletes, Diversity and Sport, Technology applications in sport, coaching education or physical education

CONTENT LEVEL: Introductory, Undergraduate

ASSIGNMENT TITLE: Inclusive physical activity promotion message design

Lecture content for instructors

Reading grade level. The majority of US physical activity promotion material is written near, or above, the eleventh-grade reading level (Thomas et al., 2018; Thomas et al., 2021b). This is problematic given the average US adult comfortably reads at an eighth-grade reading level (Kutner et al., 2006) and over 30% of US adults have low health literacy (i.e., somewhat basic to no basic health literacy; Centers for Disease Control and Prevention [CDC], 2022). Moreover, the majority of PA promotion material are written seven reading grade levels *above* recommendations from the American Medical Association (AMA) and others. The AMA suggests health promotion material should not exceed the sixth-grade reading level for effective communication (Han & Carayannopoulos, 2020). The optimal reading grade level cut-point advised for health-related material has somewhat varied among health authorities and overtime (Han & Carayannopoulos, 2020). The authors of this article use the cut-points by Doak et al. (1996): i.e., less than sixth grade (Superior), between sixth and eighth grade (Adequate), above eighth

grade (Not Suitable). It is possible to write at/below the eighth and fifth grade reading level and maintain accuracy; moreover, it can be done in a way that would not offend adults (Cardinal & Sachs, 1992; Johnson & Stern; 2004; Tse et al., 2021). The readability gap between professionally disseminated material and end-user comfort may compound inequities in health information access for marginalized populations.

Accessibility. Digital accessibility for website and social media is defined as the extent to which all consumers can easily navigate, comprehend, and engage with information (Education and Outreach Working Group, 2016). The Web Content Accessibility Guidelines (WCAG) detail best practices to ensure web-based platforms are accessible to individuals with disabilities (a quick reference guide is available from W3C Web Accessibility Initiative at www.W3C.org). WCAG Guidelines include text font and color contrast to enhance visibility of content by individuals with low vision. Additionally, guidelines include document formatting to ensure screen reader compatibility. Screen readers are a form of assistive technology that interface with digital platforms to read aloud text or facilitate hands-free page navigation. WCAG guidelines include use of alternative text for images, which requires adding metadata to images that can be read aloud by a screen reader. Specific guidelines for social media are also available (e.g. Roselli, 2018; National Center on Health, Physical Activity and Disability [NCHPAD], n.d). A practitioner's guide to using digital accessibility and inclusion features is available from Ross et al. (in press). To create accessible physical activity promotion messages, kinesiology professionals need to make design decisions (e.g. font, color, formatting) in compliance with WCAG guidelines.

Inclusion. While accessibility is about the opportunity to obtain and understand information, inclusion is signified by promotional materials that represent and respect individuals with disabilities as valued members of the physical activity community (NCHPAD, n.d.). *The Commitment to Inclusion Guidelines* center around the representation of disability communities in content, images, and program offerings (Kraus & Jans, 2014). For physical activity promotion on social media, NCHPAD advises messages include programs or resources that highlight or focus on individuals with disabilities, periodic features of disabled athletes or content applicable to disability community members and posting photos of individuals with disabilities as active participants (NCHPAD, n.d.).

Draft Assignment

OVERVIEW

Health literacy is the skills and confidence people embody to find, understand, and act on health-promoting information (Santana et al., 2021). As a kinesiology professional, you need to communicate information about physical fitness and routine physical activity behaviors that will promote clients', athletes', or students' overall

wellbeing. In our current "digital age," this information is increasingly communicated on websites and social media platforms.

To be effective, digital physical activity messages should be culturally responsive to diverse ways people obtain, process, and understand information. Digital messages need to be **accessible** so that everyone has *opportunity to obtain and engage with the information.* The information needs to be **readable** and *easy to comprehend so that all individuals can effectively make health-decisions.* Finally, messaging needs to be **inclusive** of diverse cultures, including individuals with disabilities, so that potential clients, athletes or students feel *represented and respected by the health promotion message*.

Learning objectives: By the end of this assignment, you will be able to…

- Describe readability, accessibility, and disability inclusivity guidelines for physical activity messaging on digital platforms (e.g. websites, social media),
- Evaluate digital messaging for compliance with best-practice guidelines, and
- Create a physical activity promotion message compliant with readability, accessibility, and disability inclusivity guidelines.

Instructions

- **Part I - In-class.** We will review sample physical activity promotion messaging and best practices guidelines.
- **Part II - Take-home** (individual assignment). You will revise the example messages to meet guidelines. Then you will reflect on your learning and how you might apply these skills as a kinesiology professional.

PART I

As a group, review <u>one</u> social media example below and complete question set 1 & 2. Both are examples of physical activity promotion messages from a hypothetical program: "Active Kids!"

Facebook post:

ACTIVE KIDS!

March 20, 2021

This week our skill focus stations were reaction time, jumping and landing. We played a ton of team games and fitness activities as well. I'm amazed by their energy and effort every day doing what we do best…moving! Active Kids! campers are getting in their 60 minutes a day of aerobic physical activity to help meet the national

recommendations for 6- to 17-year-olds of at least 3-days a week of moderate to vigorous physical activity for health benefits! #stayactive #healthyliving #kidsinmotion

Twitter Post:

ActiveKids @activekids Our activekids! campers were energized by our first week of strength training @stronggym! This great opportunity for adolescents of all skill levels helped them to build muscle strength and endurance through resistance training. We rotated through 1-2 sets per exercise, 10-15 reps each, with 2-3 minutes rests between sets. #strongkids 💪we 😁 are 👏strong 👏kids!

QUESTION SET #1:

1. What is the key idea being communicated in the message?
2. Was it easy for you to identify and understand the key idea? Why or why not?
3. Would the key idea be easy to identify and relate to for someone who is not a student or professional of physical education or sport education? Why or why not?

QUESTION SET #2:

1. What **reading grade level** do you think the Facebook and Twitter post are each written at?
    a. See how close your prediction is. Use the webtool below (Adamovic, 2009).
    First, paste the text into the textbox on this webpage: https://www.online-utility.org/english/readability_test_and_improve.jsp.
    Second, click the button titled, "Process text." It is toward the page bottom.
    Third, read the results for the "SMOG" formula (it is highly valid and reliable).
2. Using the guidelines below, how would you rate the example Facebook/Twitter post on **accessibility** for people with disabilities on a scale of 1-5 (highest = 5)? Why?

Accessibility feature	Guideline description	Met / Not met
Alternative text	Adds written description of an image that can be read aloud by a	

	screen reader or assistive technology.	
High contrast	Changes text and background color (invert color to black background, white text)	
Screen reader compatibility	Use meaningful headings and page organization. Use bullet points for lists rather than just indenting. Use proper sentence structure and formatting, including always ending sentences with a full stop punctuation mark (e.g., period or exclamation mark). Use CamelCase for all hashtags, #ForExample. Avoid embedding symbols or images into text. For example, "This activity will be so 👏 much 👏 fun!😍 " is read by a screen reader as "This activity will be so clapping hand much clapping hands fun! smiling face."	

3. Using the guidelines below, how would you rate the example Facebook/Twitter post on the next page for **inclusivity** of people with disabilities on a scale of 1-5 (highest = 5)? Why?

Inclusivity feature	Guideline description	Met / Not met
One	Post features individual with disabilities and/or aspects of the disability community.	
Two	When highlighting/promoting/linking to other content, resources (content, links, images, videos, buttons, badges, etc.) are included that focus on or highlight individuals with disabilities and/or aspects of the disability community.	
Three	Images include representation of individuals with disabilities and/or aspect of the disability community	
Four	Language is respectful, strength-based, and indicates individuals with disabilities are valued members of the fitness community.	

PART II - Homework

Instructions:

- ☐ Complete assigned reading/videos.
- ☐ Re-write the Facebook or Twitter message to meet readability, accessibility and disability inclusivity guidelines.
- ☐ Respond to reflection questions on what you learned from this assignment and how you can apply it as a kinesiology professional.

READABILITY

READ. People routinely turn to the internet for physical activity health information. As an educator, you may connect students/clients with websites or printed materials to share health-promoting advice. It is critical that the information shared is accessible to a wide audience. Optimizing the *readability* of your materials ensures equitable opportunity to reap the health benefits of the information shared. *Readability* is often measured by reading grade level. Most adults in the United States comfortably read at an eighth-grade reading level.

WATCH. "2017 What dreams are made of, the Literacy Project" (6:10 minutes, The Literacy Project Foundation, 2022)

> *"The statistics on literacy underscore the critical need to address illiteracy in the United States:*
>
> - *Currently, 45 million Americans are functionally illiterate and cannot read above a fifth-grade level*
> - *50% of adults cannot read a book written at an eighth-grade level*
> - *57% of students failed the California Standards Test in English*
> - *1/3 of fourth-graders reach the proficient reading level*
> - *25% of students in California school systems are able to perform basic reading skills*
> - *85% of juvenile offenders have problems reading*
> - *3 out of 5 people in American prisons can't read*
> - *3 out of 4 people on welfare can't read*
>
> *(Sources: National Institute for Literacy, National Center for Adult Literacy, The Literacy Company, U.S. Census Bureau)"*

The U.S. has committed to improving access to health-related information with the *2010 Plain Writing Act (US Census Bureau, 2021a),* and the 2010 *National Action Plan to Improve Health Literacy* (Baur, 2010).

What does this mean for physical & health education?

Dr. Thomas and fellow researchers critically examined physical activity-related educational resources on the internet (Thomas & Cardinal, 2018). They found:

- 2.5% of resources were written at an optimal or superior (≤ 5th grade) reading level,
- 42.3% were satisfactory or adequate (6^{th} – 8^{th} grade reading level), and
- 55.2% were written at an unsatisfactory or not suitable (>8th grade) reading level

"The majority of physical activity educational resources [on the internet] are written at levels that are too complex for most U.S. adults to easily read and understand." *-Thomas & Cardinal, 2018, p.110*

Plain language summaries are written to effectively communicate information and empower the consumer to make decisions based on that information. Everyone benefits from plain language summaries, not just people with disabilities.

WATCH. Video summary of "Analyzing suitability: are adult web resources on physical activity clear and useful?" (6:16 minutes; Video transcript and captions available) By Smith & Thomas [2020, September 28]. The presenters share their research findings and give advice for professionals when developing physical activity education materials.)

Dr. Thomas (2020, February 9) shares tips for writing at an 8th grade reading level or lower:

1. As much as possible, reduce the number of polysyllable words per sentence
2. Use shorter sentences
3. Before switching topics or ideas, provide context first (e.g., explains the situation)
4. Use a direct (active) writing style
5. Limit technical words. If used, define them. In general, explain ideas.
6. Use word cues (headers and subheadings)
7. Provide graphics with caption that explains the purpose of the graphics
8. State the "take home message" at the beginning.

REVIEW. More tips and resources:

- 10 tips for writing plain language summaries from the U.S. Census Bureau (2021b)
- Choose your words carefully from PlainLanguage.gov
- 10 guidelines for writing about people with disabilities from the ADA National Network (2018)
- Free Online Readability Calculator (Online-utility.org, Adamovic, 2009)

ACCESSIBILITY & INCLUSION

READ. Digital accessibility for website and social media is defined as the extent to which all consumers can easily navigate, comprehend, and engage with information (Education and Outreach Working Group, 2016). Section 508 of the Rehabilitation Act "requires that individuals with disabilities, who are Federal employees & members of the public seeking information or services from a Federal agency, have access to and use of information and data [i.e. information and communication technology, ICT] that is comparable to that provided to the public who are not individuals with disabilities, unless an undue burden would be imposed on the agency."

ICT includes:

- Computer hardware and software
- Internet and intranet websites
- Online trainings, Webinars and teleconferencing
- Multimedia such as PDFs, video, phone systems and copiers

The Web Accessibility Initiative (WAI) is an international organization working to develop Web Content Accessibility Guidelines (Henry & Dick, 2018). Their mission is to make the benefits of the Web - human communication, commerce, and opportunities to share knowledge - available to all people, whatever hardware, software, network infrastructure, native language, culture, geographic location, or physical or mental ability." The overarching principles include:

1. Information is perceivable and accessible through varied user interfaces
2. Information is operable and can be navigated through varied user interfaces
3. Information is understandable, is robust in content and has reliable interpretations through varied user interfaces.

WATCH. An example evaluation of the accessibility of digital application tools for use in physical education classrooms, "Equitable access to student curriculum: App Accessibility & Inclusion features" (39:15 minutes, video captions and transcripts available; Ross, Ross, Abrahamson, & Wyant, 2021).

REVIEW. Guidelines for accessibility and disability inclusion.

- Guidelines for Social media accessibility from Digital Accessibility, Princeton University, 2020. See also Improving your Tweet accessibility (Roselli 2018).
- Guidelines for increasing the inclusiveness of Social Media-based health communication (NCHPAD, n.d) to be more representative of people with disabilities.
    - Examples: Facebook & Twitter

HOMEWORK

REVISE. For each example message (i.e., Twitter and Facebook post), write a revised message that meets guidelines within the following categories: readability, accessibility, and disability inclusivity guidelines. Your message must:

- ☐ Convey the same meaning as the original
- ☐ Be appropriate reading grade level
- ☐ Include inclusive messaging for children with disabilities
- ☐ Include an accessible and inclusive image
- ☐ Include an accessible hashtag
- ☐ Include at least two emojis

Facebook Post: Active Kids
[insert image] Image description =
Reading grade level =

Twitter Post: @activekids
[insert image] Image description =
Reading grade level =

REFLECT. Respond to <u>each</u> of the following questions in 50 -150 words. Your response should include a position statement and supporting examples. Use terminology and concepts from this assignment and course materials. Strengthen your reflection by using specific examples of your thoughts, reactions, beliefs, perspectives and observations.

1. What was your reaction (feelings, or thoughts) to this assignment?
2. What did you learn from this activity?
3. Think about a person with a disability who might encounter your promotional message. How would their experience differ if they were presented with the first example message compared to your revised version?
4. In what ways might the <u>in</u>accessibility and <u>non-</u>inclusiveness of physical activity promotion messages impact people with disabilities?
5. In what ways could you use what you have learned in this assignment in your personal and professional life?

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The John Massengale Paper

RESEARCH QUALITY; A COLLECTIVE ENDEAVOR

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Shifflett. An allegory published nearly 60 years ago titled 'Chaos in the Brickyard' (Forscher, 1963) spoke to the decline in the quality of research. In the intervening time, greater awareness of the issues and actions to improve research have emerged. Still, problems persist. This paper is intended to clarify some of the challenges, particularly with respect to quantitative research, then suggest ways the academe can contribute, in concrete ways, to the improvement of the quality of published research. The paper highlights where feasible refinements in research design and analytical techniques can be made and provides a guide to fundamental principles related to data analysis in research.

Key Words: research design, data analysis, quantitative research

Introduction

Forscher's (1963) allegory portrayed scientists as builders constructing edifices (theory) by assembling bricks (facts). As the story 'Chaos in the Brickyard' explains, the original pride in producing bricks of the highest quality to facilitate the creation of solid edifices gave way to simply making bricks. "Unfortunately, the builders were almost destroyed. It became difficult to find the proper bricks for a task because one had to hunt among so many" (Forscher, 1963, p. 339). The ripple effect of this piece can be observed through faculty who continue to introduce their students to this commentary in order to elicit an awareness of significant design and analysis issues in research. Faculty members (from wide-ranging disciplines) may take the discussion in a particular direction (e.g., ethics, data integrity, reporting bias); yet the overall impact has likely been that students become more familiar with the problematic nature of published work than they would have been. In fact, in the author's experience, students often realize for the first time that published work might be flawed after reading 'Chaos in the Brickyard'. Forscher's allegory provides a springboard for faculty to continue the dialogue with their students and an opportunity for researchers to reflect on the status of published research today.

Turning attention then to the identification of problems along with possible strategies to address areas where publications fall short can help guide efforts to improve the quality of research and its subsequent publication. Hence, this paper seeks to focus on the foundational elements of quantitative research in order to emphasize the importance of basic principles pertaining to research design, descriptive statistics, and inferential statistics. The intention is to compile a resource that weaves together content from disparate texts and articles in a manner that supports faculty and advances discussions that address ongoing efforts to improve the quality of research.

Issues and challenges

Awareness of the wide range of issues related to the quality of publications has certainly been raised

through academic journal publications (Fischman, 2011; Knudson, 2009; Weed, 2006) and the media in general (Bower, 2013; Chwe, 2014; Kolata, 2013; Lamb, 2013; Weins, 2014). Researchers note that what continues to be a problem, and perhaps a more pronounced one since Forscher's (1963) publication, is the proliferation of research of questionable quality (Bauerlein, Gad-el-Hak, Grody, McKelvey & Trimble, 2010). It is important to make a distinction at this point between the proliferation of weak research and the proliferation of data. The problem is not the explosion of available data, often referred to as 'big data'. Big data are here to stay and researchers are beginning to understand how best to capture and use such data to good effect. A particularly good example is the work done by Silver (2012) in analyzing large volumes of data to predict election results. His success leant credibility and respect to an analytical approach to practical problem solving. The visibility of this quantitative work provided an opportunity to garner support for quantitative research. Its ongoing good reputation as a valuable resource can build public confidence in other arenas, provided publications possess comparable credibility and quality.

Consider the point made by Bauerlein et al., (2010) that the "amount of redundant, inconsequential, and outright poor research has swelled in recent decades" (p. 1). Taken as a call to change the landscape, it is a challenge worth tackling. The situation has a particularly negative impact on everyone involved when one considers the time required by researchers to read and evaluate volumes of published work to determine its relevance, quality, and connection to their own projects, in addition to the time invested in having the work assessed by editors and reviewers. A related problem is the proliferation of online journals that appear to publish work without genuine peer review or consideration of the quality of the research, provided a fee is paid by the author (Beall, 2013; Kolata, 2013). The expansion of new open-access online publication venues does increase the opportunity for the expedient distribution of research. The challenge for the researcher becomes identifying reputable online journals from among so many. A confluence of ongoing pressures on faculty to publish combined with the predatory nature of a growing number of publishers of questionable integrity may be exacerbating the 'chaos in the brickyard'. When the field becomes littered with poor quality research the task of finding solid work to build on becomes a challenge.

Bias and Fragmentation

Among the issues that frequently receive attention is bias. For example, selection bias is the practice, often associated with government agencies, businesses, and the pharmaceutical industry, of being selective in reporting research/evidence to the point where findings are misrepresented. Similarly, reporting bias is the predisposition to give less attention to, choose not to submit for review, or not publish work with 'negative' results (Editorial commentary, 2007; Pigott, Valentine, Polanin, Williams & Canada, 2013). Such bias could lead to conclusions that treatments are more useful than if research with both significant and non-significant findings were viewed as relevant. One indication of the problematic situation is the observation by Ioannidis (2005) that data mining resources are publicized for their capacity to identify significant results. This puts at the top of the list of priorities finding something (anything) significant rather than identifying and exploring important and relevant questions. One additional issue in this category is confirmation bias. This pertains to giving less scrutiny to results in line with expectations. Picture the deep and probing review of data entry, error checking, and appraisal of analytical procedures that might ensue when findings of a completely unexpected nature occur. Does that same level of scrutiny take place when findings are in line with expectations? If not, the likelihood that confirmation bias may lead to the perpetuation of inaccurate findings is cause for concern.

Another problematic practice is the piecemeal or fragmented publication of research findings. Referred to by Fischman (2011) as 'salami science', it is the practice of publishing multiple articles all derived from one study which can misrepresent the extent to which findings are statistically significant. It also gives the illusion of greater breadth and depth of study in an area than has actually taken place. While researchers have recommended the use of meta-analysis to better assemble all the various studies in

an area (Altman, 2012; Knudson, 2009; Weed, 2005; Weed, 2006), the original problem of having it appear that multiple independent studies have been conducted remains.

Research Methods and Data Analysis

Two of the issues raised in Forscher's story are equally important. The first was the lament that few aspired to be builders. The second was that the poor quality of numerous bricks would inhibit progress. Theory development and testing that emerges from theory-driven questions designed to extend the knowledge base are important (Achterberg, Novak, & Gillespie, 1985; Eisenhardt, 1989; Walshe, 2007) and builders that take us in this direction are needed. Equally important in Forscher's (1963) story, and relevant today, is the need for bricks of the highest quality. Some of those bricks will not necessarily be theory-based yet they can probe important questions that need exploration. It takes both builders and brick makers to advance our understanding in any discipline. This section focuses on the elements of basic research that impact the quality of the research produced which can subsequently facilitate, or inhibit, if of poor quality, the work of theory building.

With respect to methodological and analytical issues, the critique of research includes questionable research practices such as data manipulation, selectively altering variables, and reshaping hypotheses to support data (O'Boyle, Banks, & Gonzalez-Mulé, 2017), and how statistics are used (Bartlett, 2013; Franks & Huck, 1986; Knudson, 2009; Marteniuk & Bertram, 1999; Seife, 2011; Seife, 2014; Taleb, 2014; Vaisrub, 1991). Building quantitative research skills in the process of honing scientific literacy could prove valuable in resolving some of the problems associated with the design of research projects and subsequent application of statistics to analyze research data.

Psychometrics

The term psychometrics refers to validity, reliability, and when observations are the data source, objectivity. They can be applied to both research and data. As Claydon (2015) noted, in addition to the importance of analytical work to convey the impact of research findings beyond statistical significance (e.g., effect size), design considerations related to the internal and external validity of the research remain important when considering research rigor. With regard to the validity of research, examining internal and external validity are the key elements. Internal validity is a matter of considering the extent to which findings can be attributed to the independent variable while external validity is about the generalizability of the findings. The reliability of research is focused on the replicability of findings. Good practice calls on the researcher to consider what the threats to internal validity, external validity, and reliability (or objectivity when observations are the source of the data) of the research might be and establish protocols for data collection that minimize the threats (Brown, 2015; Thomas, Nelson, & Silverman, 2010). On this point, the methods section of most publications provides sufficient detail for readers to assess the quality of the research. More problematic is lack of attention to reporting the psychometric characteristics of the data collected.

In examining the reliability of data, of interest is its accuracy. This is typically demonstrated via consistency across repeated measures on one day (internal consistency) or over time (stability). The importance of checking and reporting reliability information for the dependent variable(s) in a study cannot be overstated (Vacha-haase, Ness, Nilsson, & Reetz, 1999). The credibility of all analyses conducted rests on an assumption that the data are accurate. The statistic needed to assess reliability is an intraclass coefficient (e.g., intraclass R or Cronbach's alpha). Though still observed in publications, an interclass coefficient such as the Pearson Product Moment correlation (PPMC) is not the most appropriate statistic for estimating reliability. The PPMC is a rank order correlation coefficient designed to convey the relationship between two different variables. It is not designed to detect inconsistency across repeated measures of the same variable; yet consistency is the central issue with reliability.

Regarding evidence of the validity of data, of interest is whether or not the data are clean (not confounded by other factors) and relevant in the context of the research question. Correlating the data from the dependent variable with a criterion measure of the same variable is an appropriate quantitative approach to gathering evidence of the validity of

data. Under conditions where a quantitative approach is not feasible (e.g., lack of a criterion measure) at least content validity (cognitive measures) or logical validity (motor skills) should be established through peer review of data collection protocols.

If the quality of the data collected for the dependent variable is questionable then there is little value in testing any hypotheses or trying to draw conclusions from the data. For each study conducted the reliability (or objectivity) and validity of the data collected should be examined.

Power, Sample size, Effect size, and Type I Error

These factors, considered in combination, are important in the design of research projects. Power pertains to the probability of correctly rejecting a null hypothesis and is influenced by sample size, effect size, and selection of alpha (type I error). Effect size conveys the magnitude of the difference or relationship found in a study. Type I error is a value selected by the researcher that sets the limit on the probability of incorrectly rejecting a null hypothesis. The important point with regard to the interconnectedness of power and other research design factors is to use the information to determine the sample size needed before a study begins (Myers, Ahn, & Jin, 2011). Once the experiment-wise alpha (type I error), power desired (commonly .80), and expected effect size (identified through pilot studies or previous research) are selected, software can be used to determine an appropriate sample size (Faul, Erdfelder, Lang, & Buchner, 2007). Post-hoc, it is equally important that power be reported as it is an important indicator of research quality (Fraley & Vazire, 2014).

Analysis of Data

A solid grasp of the basics with regard to descriptive and inferential statistics can, in a substantive way, help bring order to the 'chaos in the brickyard'. For example, central to the selection of descriptive and inferential statistics to summarize group data is an understanding of how the type of data collected impacts what statistics should be used. The information presented in Table 1 and Table 2 provides a basic guide regarding which descriptive and inferential statistics to use depending on the type of data available.

For descriptive statistics, discrete data (categorical or ordinal) are best summarized with frequencies or percentages since the numbers simply represent categories (e.g., ethnicity). When continuous data (interval, ratio) are recorded, measures of central tendency (e.g., mean, median) and variability (e.g., standard deviation) are appropriate for summarizing the data descriptively since scores are recorded.

Table 1

Descriptive Statistics for Summary of Group Data

Type of Data	Descriptive statistics
Categorical (nominal)	Frequencies, Percentages, Mode
Ordinal	Percentages, Mode, Median*
Interval	Median, Mean, Standard Deviation
Ratio	Median, Mean, Standard Deviation

Note. *The median, as a measure of central tendency, for data at the ordinal level of measurement could be acceptable provided the data do not simply represent a few ordered categories.

Table 2

Inferential Statistics for Testing Differences and Relationships (Correlation)

Type of Data	Type of Question	Inferential Statistics
Categorical (nominal)	Differences	Not Applicable
	Relationships	Chi-Squared
Ordinal	Differences	Mann Whitney, Kruskal Wallis, Wilcoxon, Friedman

	Relationships	Chi-Squared
Interval	Differences	t-tests, F tests
	Relationships	Correlation, Regression
Ratio	Differences	t-tests, F tests
	Relationships	Correlation, Regression

When testing hypotheses where the data for the dependent variable are discrete, nonparametric inferential statistics are best employed. When the data are continuous, parametric inferential statistics would be employed provided distributional assumptions are met. The chart in Figure 1 could aid in the selection of analytical techniques and help journal reviewers identify errors. While not suited to support decision-making at all levels, it does provide a framework when considering the big picture.

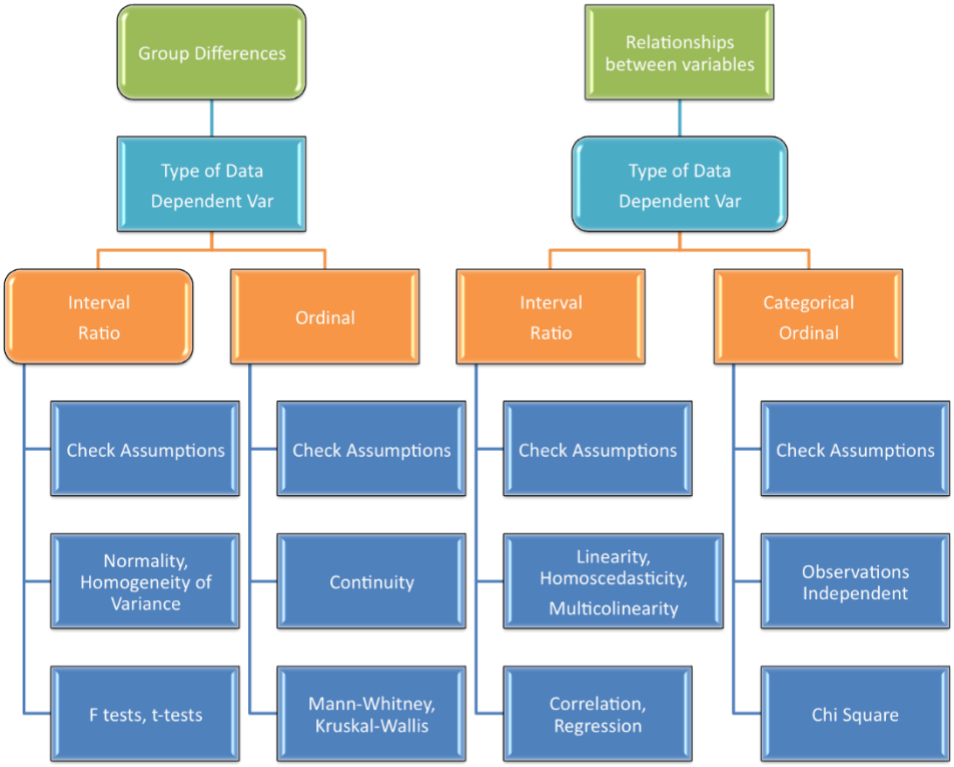

Figure 1: Flow chart for the selection of appropriate inferential analyses depending on the type of question and the data's level of measurement.

Another concern pertains to the use of demographic data as dependent variables (e.g., age) for inferential tests. Demographic information is best summarized using descriptive rather than inferential statistics. Demographic data may also be employed as independent variables in an inferential test related to the primary question(s). The distinction pertains to using descriptive statistics to inform subsequent inferential tests rather than conducting inferential tests using demographic characteristics of subjects as dependent variables.

Other basics where a firm understanding is important include (a) checking distributional assumptions and using non-parametric tests when appropriate, (b) the importance of reporting practical significance, and (c) the need to adjust the type I error rate prior to examining statistical significance when multiple inferential tests are done. The following sections elaborate on these issues.

Distributional Assumptions

Checking assumptions is an important step in the selection of appropriate analyses. For example, if the distributional assumptions associated with the parametric F test from a one-way analysis of variance (ANOVA) are violated, the non-parametric equivalent (Kruskal-Wallis Test) could be used. On the one hand a case can be made that the parametric test is fairly robust to violations of the assumption of normally distributed data and is more powerful than its non-parametric equivalent. On the other hand, if assumptions have been violated, the parametric test may misrepresent findings and a comparison based on medians, through a non-parametric test, rather than means may be more appropriate (Thomas et al., 1999). Reporting the outcome after checking assumptions, regardless of the inferential test conducted, serves two valuable functions. First, the reader has been given better context for reported results and second, the need to check assumptions associated with any inferential test gets reinforced and likely replicated by other researchers.

Practical Significance

Regarding analyses connected to the main question(s) under study, it is important to report the practical significance of the findings. It is all too common for only statistical significance to be reported. Differences or relationships that may be statistically significant are not necessarily of practical or clinical importance (Ioannidis, 2005). For example, finding a statistically significant relationship simply means that you have rejected the null hypothesis that the correlation is zero. Having established it is not zero is not the same as having established that the relationship is of practical importance. With enough subjects, a correlation coefficient of .20 (very weak) could be statistically significant. The more important point, in this example, is that practical significance, reflected in the coefficient of determination (r squared) is only .04 which means that only four percent of the variability in the dependent variable can be explained by the independent variable.

Another point to keep in mind is that what constitutes practical significance can depend on the context. For example, if a measure of leg strength when correlated with vertical jump is .60, then the value reflecting practical significance (r squared = .36) means that 36% of the variability in vertical jump can be explained by leg strength. While this number, absent context, may be interpreted as only modest practical significance, in the context of the fact that other variables like height and muscle fiber type cannot be changed, this value is more likely of substantial practical significance to the researcher, coach, or athlete considering resistance training to improve vertical jump.

The practical relevance of findings is central to theory building and the advancement of ideas. In addition, reporting effect sizes provides scholars with a way to gauge the magnitude of a difference or relationship as well as giving future scholars a key component for meta-analyses.

Adjusting Alpha

The need to adjust alpha (type I error) prior to examining statistical significance when multiple tests (e.g., multiple t-tests) are done is important. Too often statistical tests are conducted in comparison to an alpha of typically .05 regardless of how many inferential tests are conducted (Franks & Huck, 1986; Ioannidis, 2005; Knudson, Morrow & Thomas, 2014). When the experiment-wise alpha is not adjusted prior to making decisions with respect to statistical significance this could result in exaggerated claims with regard to the significance of findings and caution is called for on the part of readers when this situation is encountered. It is advisable to limit the number of inferential tests conducted or use multivariate analyses when the assumptions can be met. Otherwise, it becomes increasingly difficult to obtain statistical significance and power is sacrificed.

When multiple inferential tests are deemed important, the Bonferroni technique (Franks & Huck, 1986) is a simple approach to adjusting alpha and is easily applied; divide the experiment-wise alpha by the number of statistical tests done. This new adjusted alpha is what each p value (probability of obtaining observed results, assuming that the null hypothesis is true) is then compared to in determining statistical significance. In addition, when reporting statistical significance, it is better to report the actual p value rather than the common ‘$p < .05$’ statement (Tromovitch, 2012). It is more informative to the reader and easily obtained from software (e.g., SPSS).

In the author's view, it is not necessary for all questions of interest to be addressed with inferential tests, particularly at the cost of diminished power. The suggestion here is to identify the primary question(s) of interest and apply inferential tests in those cases. Additional questions can be effectively explored via descriptive statistics.

Simple is elegant

Vaisrub's (1991) challenge to "simplify, simplify, in a statistical Walden, I dare you" (p. 49) was a call to choose, when appropriate, analytical techniques that are not unnecessarily complex. With software to handle intricate and otherwise time-consuming computations it has become far too easy to point and click through overly complex statistical analyses. When an F test from a one-way analysis of variance (ANOVA) will answer the research question in a study, this simple analysis is appropriate. Conducting instead an excessively complex analysis because one can, may directly contribute to the 'chaos in the brickyard'. Even the choice to conduct a 2-way ANOVA should be made in the context of what is needed to answer the primary research question(s) since three F tests will be produced by the 2-way ANOVA.

In summary, each of the fundamental design and analysis factors considered in this section, when appropriately incorporated into research increases the likelihood that credible findings will be obtained. Additionally, published work serves as a model for others. This means that each publication with appropriate analyses employed has the potential to influence the quality of research subsequently conducted.

A Snapshot of the Current Research Landscape

Research conducted by Bernard, Ednie, and Shifflett (2021) provides insight into the quality of research in Kinesiology. Their content analysis examined 270 articles spanning a five-year period from 2016-2020 and was stratified into three tiers based on impact factors. Subsequently, analyses focused on (a) research quality over time, and (b) the relationship between research quality and journal impact factors ((1=high, 2=moderate, 3=low). Their dependent variable for the content analysis, quality of the quantitative analyses, was derived by documenting authors' application of basic analytical principles: (a) checking of assumptions, (b) reporting actual p values, (c) reporting practical significance, (d) adjusting alpha when multiple inferential tests conducted, and (e) reporting a measure of reliability for the study's dependent variable.

Interestingly, there was almost no variation in results depending on the tier (impact factor level) of the journal the articles came from. For example, with respect to adjusting alpha when conducting multiple inferential tests, 74%, 69%, and 71% did not adjust their alpha in studies from tier one, tier two, and tier three journals respectively. Similarly, practical significance was not being reported in studies from tier one (68%), tier two (52%), or tier three (66%) journals.

When examining the question of whether or not there was a change in quality over time, while there was a statistically significant finding (p=.021), the effect size was only .16, and practical significance was negligible (.03). Descriptively, the pattern of change is a reason for some optimism as changes over time were observed to be in a positive direction. However, that change was modest. In addition, foundational components of quantitative research were missing. For example, in 2016, 16% of the articles checked the reliability of the data and in 2020 that increased to only 21%.

Overall, one area where the analytical work was observed to have improved was the reporting of p values. Across all articles in 2016, 52% were not reporting specific p values and in 2020 that switched to 52% were reporting actual p values. There remains plenty of room for improvement but compared to other areas, this was better. In contrast, 97% of the articles that did not determine sample size in the context of power also did not report power at all for their findings. As Abt et al., (2020) notes, "it's quite likely that we have a problem with underpowered studies in sport and exercise science" (p. 1933).

Recommendations

Efforts to clear away the chaos generated by poor quality research have been made through critical reviews of published work (Bartlett, 2013; Marteniuk & Bertram, 1999), compilation of an 'authors beware' list of predatory journals (Beall, 2013), and diligent attention among many collegiate faculty to the

development of students' scientific and quantitative literacy skills. These efforts to improve the quality of research and publications are important and should continue. In addition, a more widespread approach is recommended for significant and sustainable improvement to enhance the quality of research and help reduce the 'chaos in the brickyard'.

The strategy proposed is one that could be applied to any large-scale project. Imagine a group of colleagues responsible for reviewing their institution's accreditation report and all supporting documentation. Asking all members to review everything is likely to result in duplication of effort while various components may be overlooked. Alternatively, having each person review a specific portion of the work is more likely to result in a thorough examination of all components. A similar approach can be applied to improve the quality of published research. No single person or group can improve the quality of published research. However, the following sections suggest how students and faculty, along with journal editors, can each take manageable actions that are sustainable and result in meaningful contributions to improve the quality of published research.

Student Contributions

Students are in a position to acquire the skills and knowledge needed to be critical consumers of research and to apply what they learn when the opportunity to conduct research presents itself. Depending on the curriculum, at the undergraduate level students are likely to take a measurement and evaluation course and/or a research methods course. Additionally, in other major courses faculty may assign for reading and critique discipline-specific research articles. In each case, as students gain confidence and analytical skills, their ability to discern evidence of good quality can increase to the point where, as professionals, their data-based decision-making skills are stronger.

At the graduate level, foundational skills can be further developed. Both the breadth and depth of the content of graduate level research and statistics coursework exposes students to principles that can develop a more nuanced understanding of what constitutes quality research. With a solid understanding of descriptive and inferential statistics they will be even better equipped to read and critique publications. In addition, they will be better able to conduct the analyses for projects, theses, and dissertations themselves. While many may not consider quantitative work to be their strong suit, all have the capacity to master the content to the point where they can think critically about what they read and take responsibility for design and analysis decisions for their own research.

Faculty Contributions

Teaching

At both the undergraduate and graduate levels, attention while teaching directed toward raising the awareness of students with respect to what constitutes quality research can lay a good foundation for those who will go on to conduct research in any discipline. In addition, it can provide all students with the skills needed to be more knowledgeable consumers of research. In the author's experience, nearly all undergraduate students and many masters level students need assistance in order to move beyond reading the beginning and end of research articles while skipping the analytical portion of published work. The task need not fall only on those faculty teaching a research methods, statistics, or psychometrics class. Many faculty, across diverse disciplines, assign article reviews in their classes. Including in the assignment guidelines, critique of the analytical section of articles is an important step in improving the quantitative literacy of all graduates. If each faculty member selects for inclusion even a few design and/or analysis issues for students to consider, collectively, students are likely to acquire greater breadth in their understanding of research design and analysis matters. Instilling in students a healthy skepticism for published work along with the skills to detect problems could be of considerable value.

Faculty working with masters or doctoral students can then add considerable depth to a wide range of research topics and assignments which can include activities designed to prepare graduates to serve as journal peer reviewers (Zhu, 2014). Doctoral programs can cover in much greater detail the range of analytical options to handle questions around differences and relationships and build analytical

skills beyond testing for statistical significance. In parallel, assigning 'Chaos in the Brickyard' or comparable pieces for reading and including reference to predatory publication practices would also complement efforts to enhance students' skills and knowledge with respect to research. This might not directly address the problems noted with respect to the generation of weak research, but it could help students navigate the 'chaos in the brickyard'.

Service

Turning to the service component of faculty responsibilities, there are several ways to promote quality research. Those involved in the retention, tenure, and promotion review (RTP) process can help by engaging their colleagues in discussions that favor quality research over the simple quantity of publications. Without combating the publish or perish culture, the balance in expectations can still be shifted to the point where less is more. Since faculty are the ones sitting on RTP committees they can have a direct impact on keeping expectations with regard to quantity manageable. Faculty can also advocate for resources and promote on campuses, for example, a position responsible for supporting the analytical work of faculty in the conduct and reporting of their research in addition to providing access to professional statistical consulting for all faculty; not just those with funded research.

In addition, faculty are in a position to act on the observation that journal impact factors are not necessarily indicative of research quality (Bernard et al., 2021; Fraley & Vazire, 2014; Köhler, DeSimone, & Schoen, 2020). It remains salient for faculty to have indicators other than journal impact factor reported in their dossiers when documenting their research. When connected to the efforts of faculty involved in shared governance (e.g., campus senates), university policies can be refined to value quality over quantity. This provides a framework for faculty and administrators reviewing tenure-track faculty and makes expectations clear to those being reviewed.

At first glance, it might not be clear how actions in the service area, and RTP in particular, would impact research quality. The connection is that faculty research is often done in the context of publish or perish expectations. This could lead to research choices driven by a need to quickly finish multiple projects, which potentially floods the brickyard with small-scale unrelated findings based on data from few subjects. Reigning in a quantity-focused culture in the RTP process benefits everyone. We will reach a point of diminishing returns and more 'chaos in the brickyard' if the pressure to publish results in potentially weak research distributed through publishers with poor or nonexistent standards.

For those whose service takes the form of reviewing manuscripts for publication or presentation, their responsibilities serve a critical function in keeping the profession supplied with quality research. Requiring additional information of authors when needed including checks of distributional assumptions, p values, adjustments to alpha when multiple inferential tests are done, effect size(s), and practical significance will strengthen the end product prior to publication. When analyses are not familiar to a reviewer, asking the editor to solicit review of the analytical work could prove essential and result in important changes that otherwise might not have been made. Papers need not be rejected when lacking in one or more respects. Rather, modifications can be requested prior to accepting a manuscript. Such efforts benefit both reviewers and authors while strengthening the credibility of the journal's publications. The potential to change the proportion of strong vs. weak research that drives the construction of edifices is significant.

On a related note, journal editors have a gatekeeper role that impacts the quality of published work. Beyond the responsibilities of a reviewer, an editor in concert with their editorial board can explicitly establish the basic requirements for quantitative research and host/sponsor webinars or conference meetings for reviewers and authors to reinforce good practice. Additional recommendations have included publishing clear evaluation standards, clarifying roles among editors and reviewers, protecting the time commitment of editors and reviewers, and improving reviewer recognition (Knudson et al., 2014).

Research

Bartlett's (2013) points regarding the proliferation of flawed work makes clear that good quality research begins with understanding and

questioning published work. In the research domain it is important to probe authors' work before attempting to build upon it. Otherwise, we run the risk of perpetuating weak ideas and leading others to pursue a misguided line of research.

Faculty conducting research, independently or in collaboration with others, are in an excellent position to improve the quality of published research. A focus on good quality work from the design of their research built upon a critical review of existing literature, through the implementation of a project, data analysis, and write up of the findings will benefit the entire community of scholars as well as those who base decisions and actions on published findings. Faculty can expand their own reporting when they publish to systematically include practical significance, power, psychometrics, and assumption checks. Subsequent researchers will model what they see in publications so there is a significant ripple effect to be considered.

With regard to the analysis of data, to the extent possible, each researcher should have enough of an understanding of basic descriptive and inferential statistics to ensure that appropriate analyses are conducted; even when the person actually doing the analysis may be a paid consultant. The principal researcher should be the one guiding the research design and analysis of their data to ensure that appropriate analyses are done to address well designed research questions. When in doubt, the principal investigator can and should turn to others with expertise in data analysis for assistance. Once the data are analyzed and outcomes critically examined, findings regarding statistical significance (including p values) should be accompanied by measures of practical significance, power (post-hoc), and effect size. One final point with regard to the write up of a manuscript is that keyword selection should be taken seriously. Careful consideration of what descriptors others will need to find relevant publications is important.

Conclusions/Implications

The fact that The American Statistician journal in the recent past devoted an entire issue (Volume 73; Issue sup1, 2019) to the topic of p values suggests concerns are significant and much work still needs to be done. In that issue, Wasserstein, Schirm and Lazar (2019) provided an excellent overview of the issues and challenges related to quantitative research. There is a middle ground between not taking any action and hoping things improve, and throwing out hypothesis testing entirely since there remain many problems with the analytical work and its reporting in publications. A step away from the bright-line practice of focusing on results with $p < .05$, with no consideration for practical significance or effect size, is a good place to start. This could also address the concern Head, Holman, Lanfear, Kahn, and Jennions (2015) referred to as inflation bias (selective reporting).

Faculty stand at the nexus of our capacity to impact research quality. As instructors they will influence the next generation of professionals who will rely on and/or generate future research. Recommendations outlined in this paper include incorporating quantitative research principles into curricula at the undergraduate (foundational elements) through the doctoral level (comprehensive) to enhance the quantitative literacy of our graduates.

As engaged scholars, every study published that is of good quality can illuminate the path toward broader application of sound quantitative research principles for others who will model their work on previously published articles. Whether the analytical work is simple or complex, this paper advocates for adherence to a basic set of fundamental elements of quantitative research including: (a) reporting of practical significance, effect sizes, power, and psychometrics, (b) checking and reporting assumptions for parametric and non-parametric inferential tests, and (c) adjusting alpha (type I error), when needed, prior to examining statistical significance.

The suggestions advanced here are certainly not a comprehensive list of all that can be done. Rather, they are meant to provide a catalyst for discussion and action on these and other ideas students, faculty, administrators, and journal editors might have. Members of the academic community, across all disciplines, can help in ways that are sustainable, given their roles and responsibilities, to bring order to the 'chaos in the brickyard'. The challenges did not emerge overnight; yet collectively if each person takes one small portion of the task in hand, we can

substantively change the landscape. Research of good quality provides us with information that advances our understanding of important issues in a sound and incremental manner.

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SUITABILITY: A LONGITUDINAL STUDY OF ADULT-FOCUSED PHYSICAL ACTIVITY PROMOTION WEB ARTICLES

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Thomas et al. A cross-sectional design has often been used to study the quality of health-related educational materials meant for lay adults (e.g., patients, the public). The present study addressed this research limitation. We documented the proportion of online physical activity promotion (PAP) material revised within a given time period and how quality was affected, if at all. PAP web articles (*N* = 139) meant for lay adults, written in English, and first sampled in July 2018, were resampled in July 2020. Mean publication year at timepoint 1 was 2016.82 (±1.24). At timepoint 2 it was 2018.78 (±1.39). At both timepoints, suitability for lay use was appraised using five dimensions of the suitability assessment of materials (SAM) protocol: i.e., content, literacy demand, graphics, layout and typography, and learning stimulation/motivation. There were 61 web articles (43.9%) with indicated revision and analyzed in the present study. Articles were distributed across four organizational subgroups: commercial (*n* = 21), government (*n* = 13), professional association (*n* = 10), and voluntary health agency (*n* = 17). In the aggregate sample, two SAM dimensions significantly improved: literacy demand (e.g., more active voice) and layout & typography (e.g., formatting). Often, organizational subgroups mirrored the aggregate sample. Although the overall suitability remained within the satisfactory range across the dimensions, a moderate-to-large number of articles remained unsatisfactory at timepoint 2 within several subdomains (e.g., reading grade level, summary section). This study's findings further evidence PAP materials are somewhat suitable and the need to study suitability subdomains in addition to overall suitability.

Key Words: content analysis, health communication, literacy-sensitive healthcare material, organizational health literacy

Introduction

The main objective presumed of health-related educational material is the promotion of health literacy (Smith et al., 2022). While health literacy's association with utilizing healthcare services is moderate and somewhat mixed (Degan et al., 2022), preliminary evidence suggests higher health literacy may be associated with greater utilization under certain conditions, such as when managing chronic conditions (Mackey et al., 2019). Moreover, health literacy is a strong predictor of engaging in preventative health behaviors (Berkman et al., 2011), including regular exercise and physical activity (Buja et al., 2020). Interventions and practices to promote health literacy—inclusive of health-related educational material—have a positive effect on patients'/clients' health-related knowledge, use of evidence-based self-management practices, and other health-related behaviors (Hosseinzadeh et al.,

2022; Walters et al., 2020). Given health-related educational materials are disseminated through medical office waiting rooms, organizational websites, and other online platforms, it is important that human movement professionals and clinicians are aware of research-identified quality issues that limit the ability of materials to promote health literacy and encourage preventative health behaviors (May et al., 2022). Reading grade level (RGL) is one of the most studied quality issues affecting health-related educational materials meant for lay adults (Neuhauser et al., 2013), including for physical activity promotion (PAP) materials (Thomas & Cardinal, 2020a). Thomas and colleagues (2018) systematically sampled fourteen studies that examined the readability of PAP material, published in the kinesiology and wellness literature between 1992 and 2018. Only one study investigated if RGL improved across time, which was published in 2008 by Sabharwal and colleagues. Sabharwal et al. (2008) found no correlation across a seven-year period (1999-2006). The mean RGL remained too high (i.e., M = 10.4). An RGL of 8th grade is the max cut-point for health-related material meant for lay adults (e.g., the general public, patients, or clients; Han & Carayannopoulos, 2020). Using a meta-regression analysis of the pooled studies, Thomas et al.'s meta-analytic study also showed that the effect of time was negligible (Thomas et al., 2018). Across time, the meta-mean RGL remained too high for lay use (Thomas et al., 2018).

A follow-up synthesis of the kinesiology and wellness literature, published in 2021, only located two studies that included a longitudinal analysis of PAP material RGL (Thomas et al., 2021). One was the same 2008 study by Sabharwal et al. The other was by Minoughan and colleagues published in 2018. Minoughan and colleagues observed that the mean RGL of material, focused on sport/exercise medicine from the same organization, may modestly improve over time, but any change is extremely slow and insufficient (Minoughan et al., 2018). Between 2008 and 2018, the mean RGL went from 10.4 to 8.95 (Minoughan et al., 2018). Over half of materials across the three study timepoints were above the eighth grade RGL: i.e., 85% in 2008, 84% in 2014, and 72% in 2018 (Minoughan et al., 2018). When Minoughan et al. applied the conservative SMOG formula to their own sample, the 2018 timepoint, their results were closer to the meta-mean reported by Thomas et al (2018).

Study purpose and research questions

Reading grade level (RGL) is one indicator used to judge if material would be suitable for use by lay adults. RGL fits within a broader dimension of literacy demand, according to the suitability assessment of materials (SAM) protocol developed and validated by Doak et al. (1996). Beyond literacy demand, the SAM protocol is used to assess other dimensions that influence if a lay user would deem material easy to understand and use (e.g., graphics, Doak et al., 1996; Espigares-Tribo & Ensenyat, 2021). Given the limited research attention to PAP material suitability (Thomas et al., 2018; Thomas et al., 2021), and the ongoing need to monitor material quality over time (Thomas, 2019), the present study was performed. The specific purpose was to conduct a longitudinal appraisal of PAP material suitability across several areas, including RGL. The following research questions were addressed: first, what is the rate of PAP material revision over time, if at all; second, if changes did occur, how did they affect material suitability concerning RGL and other areas, if at all; and third, if suitability changed in one or more ways over time, did change vary by production source (i.e., organizational type)?

Methods

Study design and sample

The web address of 139 unique PAP web articles written in English, meant for lay adults, and sampled in July 2018 (Thomas, 2019), were resampled in July 2020 for the present study. To be included in the present longitudinal study, the following inclusion criteria had to have been met: (a) met all inclusion criteria of the previous suitability study (Thomas & Cardinal, 2020a) and (b) had an observed indication of revision (e.g., revised title/main text). The resampling was conducted by the second and third author, with revision status verified by the first and third author (full agreement reached). Web article text were standardized for content analysis with the same techniques as the previous study (Thomas & Cardinal, 2018; Thomas & Cardinal, 2020a).

Measures

Quality was appraised using the same procedures to measure the SMOG reading grade level and the same adapted suitability assessment of materials (SAM) protocol (Thomas & Cardinal, 2020a). The protocol focused on five suitability dimensions: (a) content, (b) literacy demand, (c) graphics, (d) layout and typography, and (e) learning stimulation/motivation (for further detail, see the coding form adopted from the previous study, i.e., Supplemental Material 3. Suitability scores for dimension and overall suitability are reported as percentage points (Doak et al., 1996). SAM dimension subdomains (e.g., RGL for literacy demand) are scored using graded categories (i.e., ordinal measures), which comprise three levels/grades (Doak et al., 1996): i.e., 0 = Unsatisfactory, 1 = Satisfactory, and 2 = Optimal (like the previous study, the nomenclature by Thomas & Cardinal, 2018, was adopted). Before the second author coded the entire sample, rater agreement was piloted using a random sample subset (n = 16) stratified by four organizational subgroups. Absolute rater agreement was measured using the intraclass coefficient (ICC) statistic (one-way-mixed effect model) (Landers, 2015). Cicchetti's (1994) interpretive cut-points were used to judge the level of rater agreement. The second author's inter-rater agreement with the first author across the five SAM dimensions was good to excellent, ICC = .68-.86 (Tse et al., 2021). His intra-rater agreement was excellent, ICC = .92-.99 (Tse et al., 2021). After reaching a 100% agreement on all discrepancies, the entire sample was coded by the second author.

Analysis plan

Basic descriptive statics were computed using Microsoft Excel® and the Statistical Package for the Social Sciences (SPSS® Version 27, International Business Machines [IBM] Corporation), with the main analysis done in SPSS®. Statistical significance was set at $p \leq .05$. The paired t-test was used determine if suitability varied over time (one test for each aggregate dimension score). A significant mean difference in dimension score was followed-up with the nonparametric version of the t-test (i.e., the Wilcoxon matched-pairs sign-rank test), given that subdomain suitability scores are an ordinal measure and because the test quantifies frequency of difference. The Bonferroni multiple comparisons correction was used. To determine if suitability varied by organizational subgroup over time, the analysis of variance (ANOVA) test was conducted for each SAM dimension (Thomas & Cardinal, 2020a), which included testing for an interaction effect (i.e., time by organizational type). Any significant ANVOA test was followed up with Tukey's Honest Significant Difference pairwise-comparison test. Effect sizes were computed (e.g., standardized mean difference to the t-test; Pearson's correlation coefficient following the Wilcoxon nonparametric test), which were interpreted using established cut-points (Pallant, 2020; Richardson, 2011; Vaske et al., 2002). The Wilcoxon test measure of effect was computed manually, using the formula shown in Equation 1 (Pallant, 2020, p. 242). As standardized difference is not automatically reported within outputs to pairwise-comparisons following a significant omnibus test within SPSS, the free webtool from SocialStatistics.com (n.d.) was used. To accurately represent magnitude, the absolute value for mean-difference scores were not used when computing post-hoc effect size estimates.

$$r = |z\ value\ [i.e., the\ standardized\ test\ statistic]| \div \left(\sqrt{N[i.e., total\ \ number\ of\ observations\ across\ timepoints\ 1\ and\ 2]}\right)$$

Equation 1

Results

Descriptive analysis

Following visual and statistical assessment, the raw data was judged to have adequately met test assumptions (Motulsky, 2018; Pallant, 2020). Dependent variable data distribution was reasonably normal at both time points and by organizational subgroup (Pallant, 2020). There were 61 web articles which met inclusion for analysis, meaning 43.9% had observable revision (*M* publication year: T1 = 2016.82, *SD* = 1.24; T2 = 2018.78, *SD* = 1.39). The number of revised materials by organizational type was moderate to large: commercial (*n* = 21 of 36, 58.3%), government (*n* = 13 of 35, 37.1%), professional association (*n* = 10 of 32, 31.3%) and voluntary health agency (*n* = 17 of 36, 47.2%). Mean RGL was at the 11th grade at T1 and T2 (*p* = .590, *r* = .894, *d* = 0.07). Table 1 presents the T2 suitability breakdown by subdomain.

Table 1

Web Article Distribution Across Suitability Subdomains by Suitability Level for The Study Sample

	Unsatisfactory	**Satisfactory**	**Optimal**
Suitability subdomains	*n* (%)	*n* (%)	*n* (%)
Content			
Evident purpose	6 (9.8)	20 (32.8)	35 (57.4)
Content about behavior	6 (9.8)	12 (19.7)	43 (70.5)
Limited scope	0 (0.0)	10 (16.4)	51 (83.6)
Summary/re-view included	45 (73.8)	10 (16.4)	6 (9.8)
Literacy demand			
Reading grade level	59 (96.7)	2 (3.3)	0 (0.0)
Writing style, active voice	0 (0.0)	2 (3.3)	59 (96.7)
Vocabulary: common word use	6 (9.8)	23 (37.7)	32 (52.5)
Context before new info.	7 (11.5)	19 (31.1)	35 (57.4)
“Road signs” used	9 (14.8)	12 (19.7)	40 (65.6)
Graphics			
Cover graphic shows purpose	1 (2.6)	13 (33.3)	25 (64.1)
Type of graphics	1 (5.3)	17 (89.5)	1 (5.3)
Illustration relevance	42 (68.9)	9 (14.8)	10 (16.4)
Lists, tables, etc., explained	11 (22.9)	16 (33.3)	21 (43.8)
Graphics: captions used	11 (52.4)	5 (23.8)	5 (23.8)
Layout and typography			
Layout factors	1 (1.6)	17 (27.9)	43 (70.5)
Typography	0 (0.0)	7 (11.5)	54 (88.5)
Subheading (“chunking”) used	15 (31.3)	17 (35.4)	16 (33.3)
Learning stimulation and motivation			
Interactions used	19 (31.1)	13 (21.3)	29 (47.5)

Behaviors modeled and specific	5 (8.2)	11 (18.0)	45 (73.8)
Self-efficacy to read and motivation to understand text	24 (39.3)	13 (21.3)	24 (39.3)
Mean sample distributions	14.9 (24.5%)	15.6 (25.5%)	30.4 (49.9%)

Note. The number of samples will not always total to 61 for each row, due to exclusion of samples with "not applicable" subdomain categorization(s), e.g., did not contain a cover graphic. For greater detail on how the present findings compare to those of the previous study, see Supplemental Material 4.

Main analysis

The mean suitability score for each SAM dimension for the present sample at T1 was equivalent to scores observed in the full sample of the previous study (i.e., difference = 1-3%). According to the paired t-test, overall suitability score was greater at T2, but still within the satisfactory range: Md = +6.1%, SDMd = 9.2%, t(60) = 5.222, r = .66, p < .001, d = 0.55. This positive change was due to moderate increases within two SAM dimensions: layout and typography (Md = +13.4%, SDMd = 21.7%, r = .41, t(60) = 4.821, p < .001, d = 0.67) and literacy demand (Md = +12.3%, SDMd = 13.9%, r = .60, t(60) = 6.883, p < .001, d = 0.78). The mean suitability for layout and typography went from satisfactory to optimal, while literacy demand remained satisfactory. Table 2 presents the full summary of the paired t-test analysis.

Table 2

Results of Paired T-Test Analysis of Suitability Dimensions

	Time 1	**Time 2**				
	Mean (SD)	**Mean (SD)**	**t (df)**	**r[b]**	**p[c]**	**d**
Date published/revised	2016.82 (1.24)	2018.78 (1.39)	N/A	N/A	N/A	N/A
Content[a]	67.83 (13.00)	65.98 (18.13)	0.830 (60)	.417	.410	0.12
Literacy demand	51.64 (15.72)	63.93 (15.62)	6.883 (60)	.604	< .001	0.78
Graphics	39.17 (21.31)	44.47 (21.36)	1.642 (60)	.301	.106	0.25
Layout and typography	65.30 (20.54)	78.69 (19.22)	4.821 (60)	.406	< .001	.67
Learning stimulation, motivation to read/understand text	64.62 (22.08)	63.66 (24.82)	0.431 (60)	.732	.668	.04
Overall suitability score	57.62 (10.33)	63.74 (11.65)	5.222 (60)	.658	< .001	0.55

Notes. **SD** = one standard deviation. **df** = degrees of freedom. **r** = Pearson's correlation. **p** = probability value. **d** = Cohen's standardized difference for within-group comparison. The suitability score are percentage points, which have the following interpretive cut-points: 0-39% = *Unsatisfactory*, 40-69% = *Satisfactory*, and 70-100% = *Optimal*. The date estimation for timepoint 1 is based on 51 cases (10 did not provide date information: 5 from commercial, 1 from governmental, 0 from professional association, and 4 from voluntary health agency). The date information for timepoint 2 is based on 49 cases (12 did not provide date information: 6 from commercial, 1 from governmental, 0 from professional association, and 5 from voluntary health agency). Interpretive cut-points for the standardized difference (*d*) are as follows: .20 = small/minimal, .50 = moderate/typical, .80 = large/substantial.

[a]The statistical assumption of equal variance was supported for all categories listed, except for the Content category (p = .030), but this violation had a moot effect on all statistical estimates (e.g., *p*, *CI*).

[b]All comparisons were significantly correlated ($p < .05$), with a magnitude ranging from moderate/typical to large/substantial.

[c]The Bonferroni adjusted p-value for six consecutive comparisons was $p = .008$. Values equal to or less than .008 were considered statistically significant at a $p \leq .05$.

According to the Wilcoxon follow-up test, layout and typography scores for the aggregate sample improved within a significant number of materials by one or more levels within two of three subdomains (both p < .001): layout factors (26 increases, r = .41) and typography (31 increases, r = .48). These changes in magnitude were moderate/typical. Most materials went from satisfactory to optimal in both cases. For literacy demand, scores improved by one or more suitability level for two of the five subdomains (both p < .001): active writing voice (34 increases, r = .49), context-first (40 increases, r = .49). Most materials went from unsatisfactory to satisfactory for writing voice, and from unsatisfactory to optimal for context-first. Finally, there was a significant but small decrease in the number of material with satisfactory/optimal "road signs," p = .002, r = .28. However, 65.6% of material remained optimal in this subdomain at T2. Table 3 presents the full summary of the Wilcoxon follow-up test.

Table 3

Results of Wilcoxon Follow-up Test: Aggregate Sample Suitability Subdomain Changes

	Unsatisfactory	**Satisfactory**	**Optimal**	**z**	**p[i]**	**Effect size[j]**
Layout factors[a]	T1 = 1	T1 = 41	T1 = 19	4.536	< .001	.41
	T2 = 1	T2 = 17	T2 = 43			
Typography[b]	T1 = 0	T1 = 37	T1 = 24	5.303	< .001	.48
	T2 = 0	T2 = 7	T2 = 54			

Subheadings and chunking[c]	T1 = 13	T1 = 16	T1 = 21	1.182	.237	.12
	T2 = 15	T2 = 17	T2 = 16			
Reading grade level[d]	T1 = 58	T1 = 3	T1 = 0	0.447	.655	.04
	T2 = 59	T2 = 2	T2 = 0			
Writing style, active voice[e]	T1 = 4	T1 = 30	T1 = 27	5.409	< .001	.49
	T2 = 0	T2 = 2	T2 = 59			
Vocabulary[f]	T1 = 3	T1 = 35	T1 = 23	1.342	.180	.12
	T2 = 6	T2 = 23	T2 = 32			
Context given first[g]	T1 = 37	T1 = 13	T1 = 11	5.505	< .001	.49
	T2 = 7	T2 = 19	T2 = 35			
Learning aids via "road signs"[h]	T1 = 2	T1 = 6	T1 = 53	3.070	.002	.28
	T2 = 9	T2 = 12	T2 = 40			

z = the standardized test statistic (z-score) used to determine if difference scores were greater than zero. **p** = probability value. **Effect size** = measure of magnitude in association/difference. **T1** = timepoint 1. **T2** = timepoint 2.

[a]26 positive differences, 2 negative differences, 33 ties.

[b]31 positive differences, 1 negative difference, 29 ties.

[c]5 positive differences, 9 negative differences, 31 ties (does not sum to 61; for several cases, coding for subheading/chunking was not applicable).

[d]2 positive differences, 3 negative differences, and 56 ties.

[e]34 positive differences, 1 negative difference, and 26 ties

[f]13 positive differences, 7 negative differences, 41 ties

[g]40 positive differences, 2 negative differences, 19 ties

[h]3 positive differences, 19 negative differences, 39 ties

[i]Bonferroni adjusted p-value: for Literacy Demand subdomains (five consecutive comparisons) the adjusted p-value was p = .01, for Layout and Typography subdomains (three consecutive comparisons) the adjusted p-value was p = .017. For Literacy Demand subdomains p-values ≤ .01, and for Layout and Typography subdomain p-values ≤ .017, were considered statistically significant at $p \leq .05$.

[j]The measure to determine the magnitude of difference (effect size) was the Pearson correlation (r). Interpretive cut-points for Pearson's correlation are as follows: .10 = small/minimal, .30 = moderate/typical, and .50 = large/substantial.

Subgroup analysis

ANOVA test for interaction (i.e., time x organizational type) was nonsignificant for each SAM dimension (all p > .05), suggesting any changes in suitability were due to organizational type rather than the general passage of time. The only difference in SAM dimension scores was for content, $F(3,60)$ = 4.502, p = .007, partial η2 = .192. Commercial sources had negative difference in mean-difference scores compared to professional association (p ≤ .05, g = 1.09) and voluntary health agency (p ≤ .05, g = 0.85). The latter two had descriptive but nonsignificant increases in that dimension. Commercial was the only subgroup with a significant decrease (p ≤ .05, g = 0.66), going from optimal (MT1 = 70.8%) to satisfactory (MT2 = 58.9%).

Exploratory analysis

The aforementioned observations suggested that meaningful within-organization changes occurred in how materials were distributed across the three grades of suitability at the subdomain level, though not to the extent permitting detection of significant between-group differences. Paired t-tests were performed for each organizational subgroup across the five SAM dimensions (exploratory analysis significance cut-point set at p ≤ .10) (Vaske, 2019), with a Wilcoxon follow-up for significant results. The significant cut-point was adjusted using the Bonferroni correction concordant with the number of comparisons made for a given analysis (e.g., comparison count was 5 for analysis across SAM dimensions; the count varied if Wilcoxon follow-up was justified, e.g., the content dimension has four subdomains, whereas the literacy demand dimension has five).

Results of the exploratory analysis showed within organization variation in suitability, or lack thereof, mirrored patterns observed in the aggregate sample. Like the aggregate sample, suitability may improve in some areas, whilst decreasing or not changing in others. Decreases were observed, but there was only one significant within-organizational decrease (reported previously). Significant increases occurred for literacy demand, as well as for layout & typography within two groups: commercial and voluntary health agency. Wilcoxon follow-up tests showed that while a focus on behavior decreased in 43% of commercial material, the commercial group had an increase in material using the active voice (i.e., +52% of materials), giving context first (i.e., +76% of materials), and using a clear layout and easy to see font (i.e., +38% and +62% of materials, respectively). For voluntary health agency concerning literacy demand, active voice and context-first had zero decreases and 59% of material had a positive change. Similar trends were observed for layout and typography.

Discussion

Cross-sectional research of health-related educational materials consistently finds several issues limiting their ability to promote health literacy (Thomas et al., 2018). However, results of the present study confirm that if organizations make changes to PAP materials, then readability and other areas of suitability may be improved (Thomas & Cardinal, 2020a). Still, caution is warranted. Results also showed aspects of suitability may decrease over time or not improve in crucial areas. As such, intentional and informed efforts are clearly required (Ross & Thomas, 2022; Smith et al., 2022).

The improved suitability in factors affecting readability directly (i.e., literacy demand) and indirectly (e.g., layout) was significant, suggesting a focus of material revision is on aesthetic and personable objectives. At T2, the entire sample used active writing (96.7% of material graded as optimal). Over 80% of the sample used a lay vocabulary or explained technical terms (52.5% of material graded optimal). At T1 (previous study sample), the percent of optimal materials within the aforementioned subdomains were lower in comparison to T2: i.e., formerly 48.2% (for active voice) and 40.3% (for vocabulary/explanation), respectively. For context-first, 65.5% of material were unsatisfactory at T1. Regarding layout and typography, it is reasonable to suspect the significant improvements in the observed subdomains would make for a more pleasing reading experience. For example, adding greater space between text and visibility to text could make it easier for readers to locate specific content (e.g., skip around; Ross & Ross, 2021). We also observed a larger number of materials prompting optimal interaction at T2 compared to T1. These changes could foster deeper learning, for example by eliciting readers to distinguish between ideas or to reflect about their own health/activity status.

While aesthetic and personable designs may enhance engagement duration, they may not be enough to promote basic health literacy or higher. The actual ease of reading within the present sample (i.e., reading grade level, RGL) remained unsatisfactory. Paradoxically, the changes affecting literacy demand resulted in the same mean RGL. While active writing and a suitable vocabulary were often used, the writing was seldom concise. These observations suggest a gap in knowledge on the need to reduce material RGL and to be concise (Kakazu et al., 2018; Warde et al., 2018). Consider that over 40% of US adults lack adequate health literacy (US Centers for Disease Control and Prevention [CDC], 2022). This means after reading PAP material, many may not accurately summarize key points, nor understand how to use what they read to make health decisions or plan health behaviors (CDC, 2022; Maneze et al., 2019). Of further concern, nearly 74% of materials lacked a summary of key points. While graphic suitability improved by a moderate degree, two issues remained: (a) 52% of materials contained graphics missing captions and (b) 69% of materials contained graphics with an unclear relation to article text.

Finally, this study documented preliminary evidence that improvements observed in the aggregate sample may be driven by certain types of content producers (i.e., organizational subgroup). These changes may be confined to two aspects of suitability and not necessarily in the areas research suggests should be prioritized (Smith & Thomas, 2020). The findings add further evidence in how organizations may vary (Han & Carayannopoulos, 2020). A significant decrease in suitability occurred in one area for one organizational type within the sample of material analyzed for the present study. Organizations, however, were more similar than different. They all largely mirrored the aggregate sample. This suggests a need to partner with diverse organizations in improving their material rather than assuming some produce more suitable material than others.

Study limitations

Our analysis is not without limitations. While our study showed the need to improve web articles resampled in the present study, we are unaware why the articles were revised in the first place. It is unknown if the articles were selected for revision due to inaccurate content, to obtain advertising revenue, or to improve article suitability (Berry et al., 2011; Cardinal, 2002; Thomas et al., 2022; Thomas & Cardinal, 2021). Additionally, we did not evaluate the consistency of the articles' statements with the current physical activity guidelines, so it is not clear if the messages of the articles are in line with appropriate physical activity guidelines (Thomas & Cardinal, 2020b). Furthermore, our findings are limited to generic categories of content producers, namely organizational type. Therefore, our findings may vary when compared to results for specific organizations (May et al., 2022) or for content produced by a specific person (Gal & Prigat, 2005). Moreover, the SAM protocol is an indirect measure of the extent end-users may value and comprehend material, as well as see material as supportive to meeting their health or fitness goals. This means our results do not fully predict how end-users will process material content or react to material messages

(Espigares-Tribo & Ensenyat, 2021). Strengths of our study include our training of reviewers and use of validated measurement tools. Specifically, we used the SAM protocol in the present study, which has been shown to be a valid (Clayton, 2009) and reliable method for analyzing health material quality (Hoffmann & Ladner, 2012; Thomas & Cardinal, 2020a).

Conclusion

The knowledge base about which health-related materials change or not, in terms of their suitability, has relied mainly on cross-sectional research, with a predominant focus on measuring reading grade level. The present study advances this important area of knowledge translation surveillance through a direct longitudinal analysis of physical activity promotion (PAP) web materials, using multiple measures of suitability for health literacy promotion. Limitations of the present study were identified and briefly discussed in terms of directions for future research. The findings to the present study suggest PAP materials disseminated by health-related organizations or clinicians may often have features that make them somewhat suitable for health literacy promotion. The findings of the present study further suggest, however, that selectors and producers of materials operate in an organizational culture that values/normalizes personable and engaging writing, rather than using precise techniques for improving a range of suitability issues (Kim & Lee, 2016; Kiser et al., 2012). These findings further evidence a need to study factors shaping an organization's level of health literacy (i.e., organizational health literacy), which is the degree to which organizations make their health-related materials easy to locate, understand, and use in support of health promotion (Santana et al., 2021).

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LOCAL HEATING AND COOLING WITH ISOMETRIC EXERCISE TRAINING AS A STRATEGY TO IMPROVE SIZE AND PERFORMANCE

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Feng et al. The purpose of this study was to explore the effects of local heating and cooling with isometric exercise training of upper arm and forearm. College-aged (n=12; 21±1 y) volunteers performed 4-wk isometric exercise training of the non-dominant arm (upper arm, isometric bicep curl; forearm, handgrip), while the dominant arm served as the control. Training was performed 3x/wk and consisted of 1 set of isometric handgrip and bicep curl until volitional exhaustion at 60% pre-training MVC for the forearm (handgrip) and 1RM for the upper arm (bicep curl). Randomized ordering of heating (40°C; 15 min) and cooling (12°C; 15 min) preceded each training session. Indirect assessment of muscle size (fat-free cross-sectional area [FFCSA]) was made before and after the training period via skin fold and limb circumference measures. Biceps 1RM increased significantly ($p < 0.05$) after the intervention in both conditions (trained: +6%; control: +7%), whereas only the control arm increased time to fatigue (+40%; $p < 0.05$). FFSCA of the upper arm remained unchanged (p>0.05) in both conditions. An effect of time was noted for forearm MVC (+8%; $p < 0.05$), while both groups increased ($p < 0.05$) time to fatigue (trained: +82%; control: +64%). A trend toward an effect of time was also noted for FFCSA of the forearm (+3%; p <.10). While the intervention employed here led to many notable adaptations, the thermal stress did not appear to exert a clear benefit. Coupled with the practicality and feasibility, improving size and performance in such a short time frame has therapeutic and ergogenic aid implications.

Key Words: isometric exercise, heating and cooling, fatigue, exercise performance, skeletal muscle

Introduction

Modulation of body temperature appears to have originated as far back as 3500 BC by Edwin Smith Papyrus and later by the Hippocratic school of medicine as early references are made regarding the impact of cold as a therapeutic modality (Wang et al., 2006). Interest in cold stress as an ergogenic aid is much more recent as it was not until World War II and the decades that followed that concerted scientific efforts were made (Kelso & Reinhardt, 1943; Walker, 1949). To this point, work on cold stress (e.g., cold-water immersion, etc) has been predominantly directed towards maintaining core temperature during prolonged aerobic exercise (AE). This makes sense given the heat-producing nature of AE and the tendency of this heat to accumulate and increase core temperature. A consequence of this predilection of exploring the effects of cold stress in the context AE has resulted in comparatively little attention devoted to the potentially ergogenic effects of cold stress on resistance exercise (RE). Given the longstanding presumption that heat accumulation/application with exercise is not favorable, even less consideration has been given to potential beneficial interactions between heat and cold on RE.

Though not all studies agree, substantial literature exists showing application of cold directly

to an exercising region of muscle acutely reduces maximal strength (Bergh & Ekblom, 1979; Grose, 1958; Holewijn & Heus, 1992; Johnson & Leider, 1977; Kwon et al., 2013), while also exerting an important anti-fatigue effect (Bacon et al., 2012; Clarke et al., 1958; Edwards et al., 1972; Galoza et al., 2011; Holewijn & Heus, 1992; Kwon et al., 2013; Lind, 1959; Verducci, 2000). For example, early studies report ~11-to-21% decrease in maximal strength following limb cold water immersion (10-15°C for 8-30 min) (Grose, 1958; Johnson & Leider, 1977) whereas application of ice or cold packs to exercising muscle has been shown to increase the volume of work completed by ~15-26% (Bacon et al., 2012; Galoza et al., 2011; Thornley et al., 2003; Verducci, 2000). While it is becoming accepted that local cold exposure may improve fatigue-resistance, mechanistic underpinnings remain unclear. Current explanations include greater local muscle reflexes and excitability, altered motor unit recruitment patterns, increased neurotransmitter signaling, local analgesic effect, and/or reduction in perceived effort (Hopkins et al., 2002; Kwon et al., 2010; Palmieri-Smith et al., 2007; Prentice, 1982; Racinais & Oksa, 2010). Given the highly exothermic nature of metabolic reactions, it is also possible that precooling aids the maintenance of temperature homeostasis in muscle, thereby averting other molecular mechanisms that induce fatigue (e.g., acidosis, Ca^{2+} handling, etc) (Cheng et al., 2018).

Compared to application of cold to skeletal muscle, much less is known about the effects of acute heat stress on strength and fatigue (Latella et al., 2019). Studies that have evaluated direct, local application of heat to skeletal muscle generally show no effect (Holewijn & Heus, 1992; Long & Hopkins, 2009; Thornley et al., 2003) or an increase (Mallette et al., 2021) in peak force or torque. Interestingly, heat applied to a working limb reduces discomfort, thereby increasing exercise tolerance (Stadnyk et al., 2018). Furthermore, heat augments motor unit recruitment patterns, which is suspected to contribute to enhanced muscle performance (Mallette et al., 2021) and heat applied 1 d prior to RE enhances recovery (Nosaka et al., 2006). While applying heat may increase muscle strength, it also reduces fatigue resistance (Holewijn & Heus, 1992; Sargeant, 1987; Thornley et al., 2003). Central temperature is believed to govern neural drive to muscle (Racinais & Oksa, 2010). Therefore, local heating may exert its effects on muscle performance via peripheral mechanisms (e.g., ion channel behavior, depolarization patterns, etc.).

In general, when recovery is carefully considered, the volume of resistance exercise performed during training is directly related to the magnitude of adaptation. Therefore, identifying practical approaches to enhance training volume are of interest. Given the previously reported benefits of independent heat and cold exposure to exercising muscle, our intention was to explore alternated local heating and cooling in combination with isometric exercise training. We hypothesized that this form of thermal stress prior to exercise training sessions would lead to improved size and performance. Coupled with the practicality and feasibility of the intervention employed here, improving size and performance in such a short time frame may have therapeutic and ergogenic aid implications.

Methods

General overview

Twelve healthy college-aged males (*N*=8) and females (*N*=4) participated in this study. Participants were recruited from the greater Chico, CA area by personal interaction. All participants were screened based on ACSM guidelines (Riebe, 2018). Medical health history and physical activity readiness (PARQ) questionnaires were completed to determine eligibility. Participants with prior skeletal muscle injuries, inflammatory diseases, participation in formal exercise training, or heating/cooling treatment in the prior 6 mo**nths** were excluded. The study was approved by the Institutional Review Board at California State University, Chico (#28089) and followed Helsinki Declaration ethic guidelines for human research of 1975 which was later updated at the World Medical Assembly in Fortaleza. All study procedures, risks, and benefits were explained to participants before they gave written consent to participate.

Experimental protocol

This is a randomized contralateral limb-controlled study based on work by Stadnyk et al (Stadnyk et al., 2017). The intervention utilized here consisted of 4-wk control and exercise training conditions (Figure 1).

Each participant's dominant arm served as the control (no exercise and no heating/cooling) while the contralateral arm participated in the exercise training program (exercise + heating/cooling). Anthropometric and pre- and post-intervention size and performance assessments were conducted in the control and contralateral arms.

Pre- and post-intervention assessments

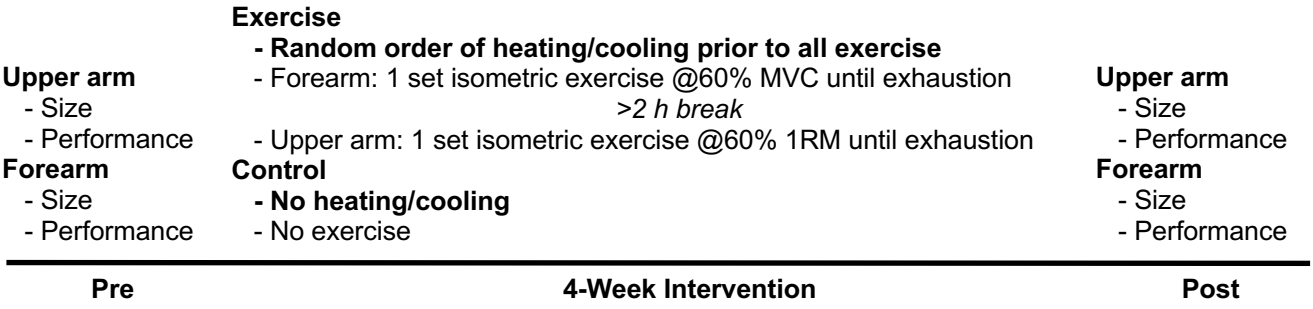
Participant age, height, weight, BMI, resting HR, and resting BP was determined before and after the intervention. Size is reported here as fat-free cross-sectional area (FFCSA) of the forearm and upper arm and was calculated to estimate lean mass (Aghazadeh et al., 1993; Bishop et al., 1987). The equation utilized to determine FFSCA was:

Equation 1. $FFCSA = \pi[(c/\pi) - (SKF/2)/2]^2$

In equation 1, c refers to limb circumference, SKF is skinfold measurement at the designated site, and π is the constant 3.14159. The largest limb circumference was recorded to represent c for the upper arm (between olecranon and acromion process) and forearm (between olecranon process and distal radioulnar joint). SKF was assessed at the triceps (vertical fold on the posterior midline, midway between the acromion and olecranon processes) for the upper arm and midway between the olecranon process and distal radioulnar joint on the lateral side for the forearm. SKF measures were taken via Lange skinfold calipers (Beta Technology, Santa Cruz, CA, USA) on the right side of the participants body in the resting position (i.e., arm resting at side) in triplicate with mean values recorded.

Figure 1

General Study Overview



Notes. General study overview. Briefly, pre- and post-intervention size and performance assessments were conducted in the control and contralateral arms. See Methods for more detailed information.

Performance was evaluated in two ways, maximal strength (i.e., upper arm 1RM and forearm MVC) and time to fatigue (i.e., upper arm and forearm sustained isometric exercise). 1RM was determined via unilateral dumbbell curl in the seated position, with feet flat on the floor, and included an initial self-selected dynamic warmup followed by a progressive increase in weight until failure (brief rest between completed repetitions; ~2 min). A successful repetition was determined when the dumbbell was raised in a controlled fashion from the resting 180° position to full flexion of the biceps (dumbbell approaching glenohumeral joint). A brief period of rest (~2 min) was permitted between 1RM determination of each arm. MVC was reported as the maximum amount of force developed during 3 attempts via unilateral Jamar hydraulic dynamometer (J.A. Preston Corp., Clifton, NJ, USA) handgrip exercise. Each MVC attempt was completed in the seated position, feet flat on the floor, with the arm completing the exercise in a 90° joint angle (~2 min rest between attempts). Before the initial attempt, handle position was adjusted to ensure good fit with the participant's hand. Upper arm fatigue was

evaluated via unilateral, isometric/static dumbbell curl at 60% 1RM. Testing was performed in the seated position, feet flat on the floor, with the arm completing the exercise maintained at a 90° joint angle. Time to fatigue was noted when the arm performing the exercise failed to maintain a 90° elbow joint angle. Forearm fatigue was assessed via unilateral, isometric handgrip exercise at 60% MVC. Testing was performed in the seated position, feet flat on the floor, with the arm completing the exercise maintained at a 90° joint angle. Time to fatigue was noted when the arm performing the exercise failed to maintain 60% MVC (i.e., failed to maintain prescribed tension on the handgrip dynamometer). At least 15 min rest separated upper arm and forearm fatigue testing.

Exercise training program

Exercise training was only completed by the non-dominant exercise arm (control arm did not exercise). Exercise was performed 3x/week with at least 24 h rest between training sessions. Each training session consisted of 1 set to fatigue at 60% 1RM (upper arm) and 1 set to fatigue at 60% MVC (forearm) separated by at least 2 h. Each set completed (upper arm and forearm) during training was preceded by a randomized order of heating (40°C, 15 min) and cooling (12°C, 15 min). Heating and cooling was applied via a temperature controlled gel pack with adjustable strap. Temperature of the gel pack was adjusted via microwave (heating) and overnight cold freezer storage (cooling). Gel packs were applied to the upper arm/forearm when the appropriate temperature was reached.

Statistical analyses

Data were analyzed via SPSS v. 28.0 (IBM SPSS, Chicago, IL, USA). A paired t-test was performed to compare pre- and post-intervention anthropometric characteristics. A two-way ANOVA (condition x time) with repeated measurement was utilized to evaluate size and performance in response to the intervention in the control and exercise arms. Pearson correlation coefficient was completed to explore potential relationships among participant characteristics and main outcomes (size and performance metrics). Data are reported as mean ± SE. Significance was set at $p < 0.05$.

Results

General participant characteristics are presented in Table 1. Given the short duration of this intervention, no differences to age, height, weight, or BMI were noted ($p > 0.05$). However, resting HR increased 10% following the 4-wk intervention period ($p < 0.05$).

Table 1

General participant characteristics.

Time	Age (y)	Height (cm)	Weight (kg)	BMI (kg/m^2)	Resting HR (bpm)	Resting SBP (mmHg)	Resting DBP (mmHg)
Pre (n=12)	21 ± 1	173 ± 2	70 ± 2	24 ± 1	68 ± 2	114 ± 3	68 ± 2
Post (n=12)	21 ± 1	174 ± 3	71 ± 3	24 ± 1	74 ± 3*	116 ± 3	71 ± 4

Notes. Values are mean ± SE; n, number of participants; y, year; cm, centimeters; kg, kilograms; m, meter; bpm, beats per minute; mmHg, millimeters of mercury; HR, heart rate; BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure *$p < 0.05$.

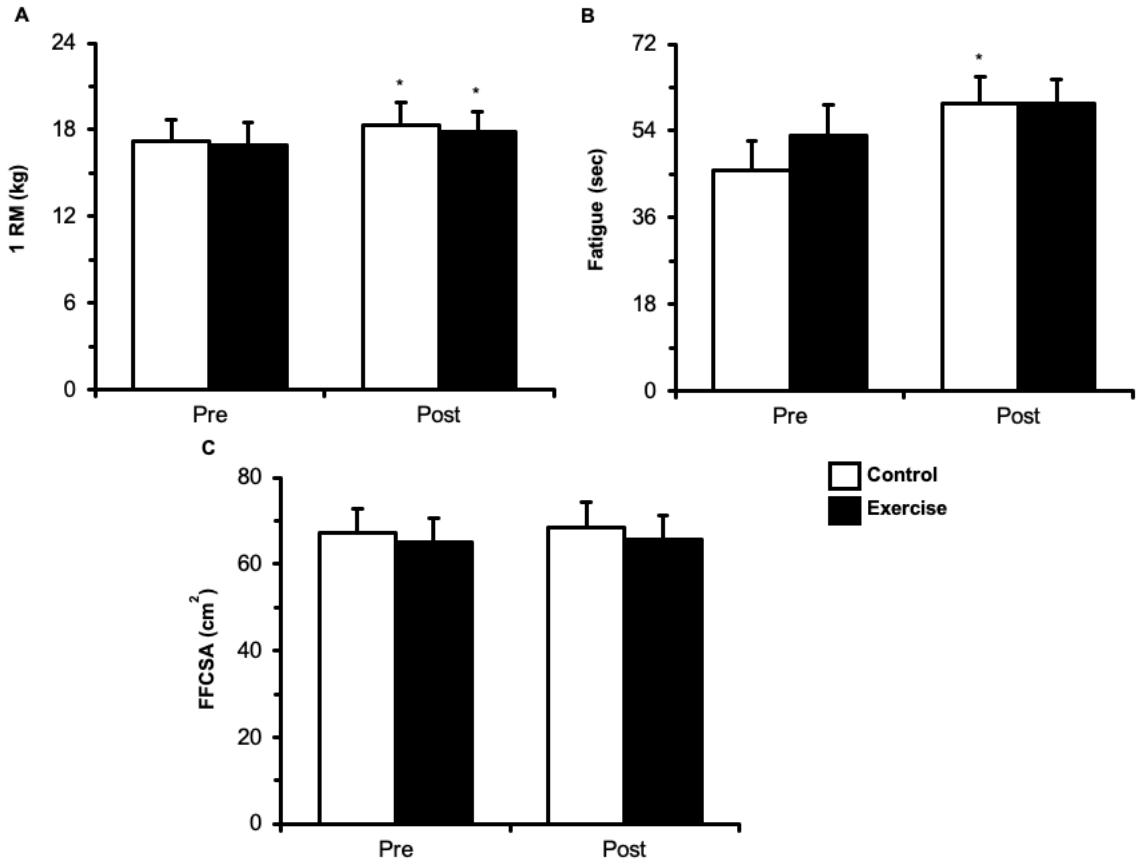
Upper arm

Performance. Maximal biceps 1RM strength (Figure 2A) increased significantly ($p < 0.05$) in the exercise trained (+6%) and control arms (+7%). While the exercise trained arm increased time to fatigue (+25%; Figure 2B) this change did not reach statistical significance ($p > 0.05$). The control arm did realize an increase (+40%; $p < 0.05$) in time to fatigue in response to the intervention period.

C*ross-sectional area.* No change ($p > 0.05$) in fat-free cross-sectional area (Figure 2C) of the upper arm was noted after the intervention.

Figure 2

Upper Arm Size and Performance



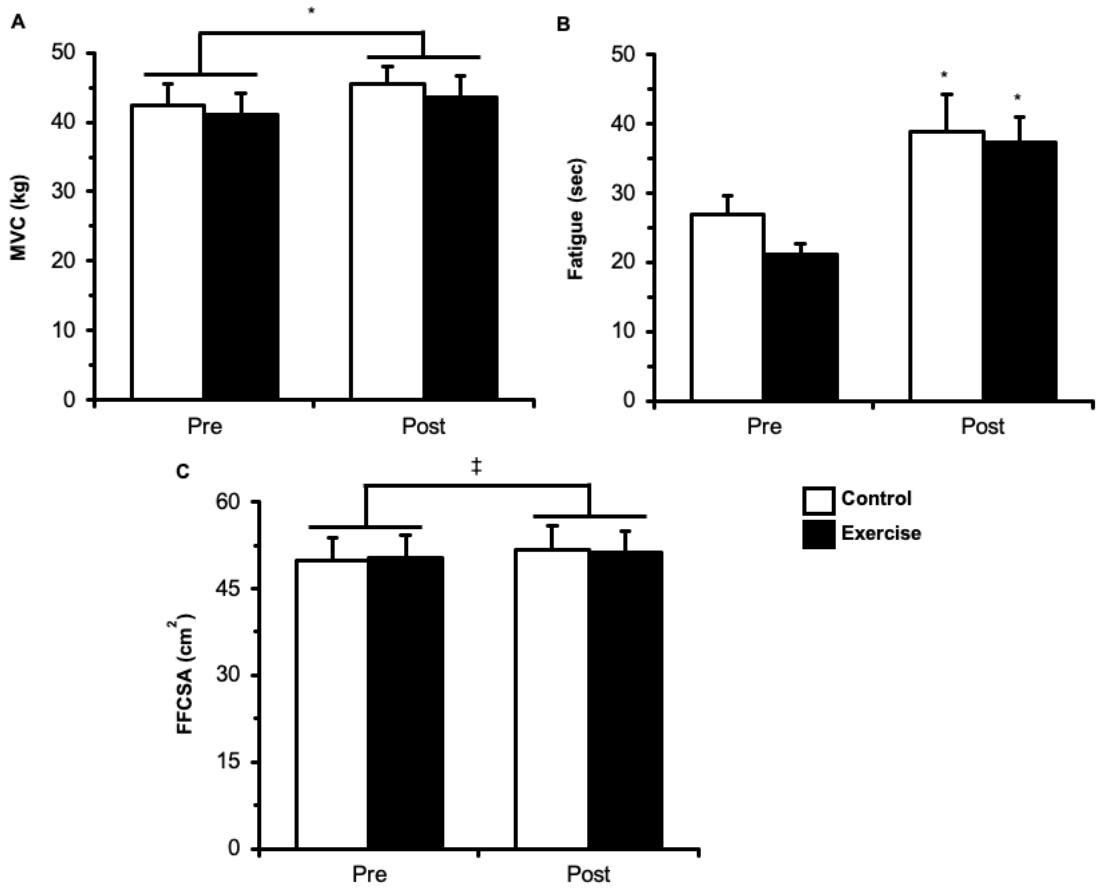
Notes. A) 1-repetition maximum (1RM), B) time to fatigue, and C) fat-free cross-sectional area (FFCSA) of the upper arm before and after the 4-wk intervention period. See *Exercise training program in Methods*). *$p < 0.05$ vs Pre.

Forearm

Performance. The intervention did not affect MVC in the exercised trained or control arm ($p > 0.05$; Figure 3A). However, an effect of time was noted for MVC, where both groups combined increased handgrip strength 8% ($p < 0.05$). Time to fatigue (Figure 3B) increased significantly in the exercise trained (+82%) and control arms (64%).

Figure 3

Forearm Size and Performance



Notes. A) Maximum voluntary contraction (MVC), B) time to fatigue, and C) fat-free cross-sectional area (FFCSA) of the forearm before and after the 4-wk intervention period. See *Exercise training program in Methods*). *$p < 0.05$ vs Pre. ‡$p < .10$ vs Pre.

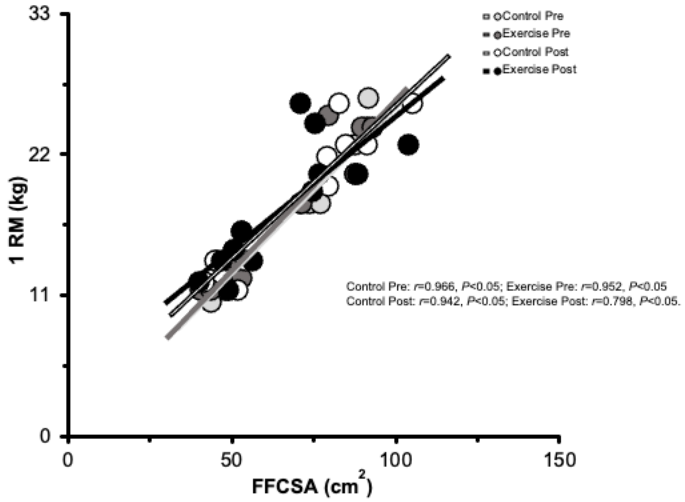
C*ross-sectional area.* Fat-free cross-sectional area (Figure 3C) of the forearm did not change ($p > 0.05$) in the exercise trained or control arms in response to the intervention. However, a trend toward an effect of time was noted, where both groups combined increased FFCSA 3% ($p < .10$).

Select relationships

Many notable relationships between performance and size were observed before and after the intervention period. As anticipated, upper arm 1RM was closely related to FFCSA in the control and exercise arms before and after the intervention (Figure 4; $r = 0.798$ to 0.966, $p < .10$ to $p < 0.05$). Interestingly, the relationship between forearm MVC and FFCSA appeared to increase in the control (Pre: $r = 0.537$, $p < .10$; Post: $r = 0.865$, $p < 0.05$) and exercise (Pre: $r = 0.691$, $p < 0.05$; Post: $r = 0.879$, $p < 0.05$) arms in response to the intervention. Time to fatigue in the forearm was related to FFCSA before the intervention ($r = 0.55$, $p < 0.05$) in the control arm, but not after ($r = -0.185$, $p > 0.05$). Similarly, time to fatigue in the upper arm was related to FFCSA before the intervention ($r = 0.578$, $p < 0.05$) in the exercise arm, but not after ($r = -0.003$, $p > 0.05$).

Figure 4

Forearm Size and Performance



Notes. Association between 1-repetition maximum (1RM) and fat-free cross-sectional area (FFCSA) of the upper arm before and after the 4-wk intervention period.

Discussion

The overarching purpose of this study was to explore alternated local heating and cooling in combination with isometric resistance exercise training. Identifying novel, practical exercise interventions are important as they have implications for enhancing performance and rehabilitation. The heating and cooling strategy employed here was selected for several reasons, including 1) the suspected effects of these stresses on improving strength and fatigue resistance, 2) feasability regarding economics and necessary expertise, and 3) unexplored nature of combined heat/cold stress. Overall, our approach was to employ practical methology that maximizes training quality and translation into clincial settings. Contrary to our original hypothesis, there did not appear to be a clear benefit of alternating heat and cold stress prior to training sessions. Principle findings show increased maximal strength of the upper arm and forearm (both groups), fatigue resistance of the upper arm (control only) and forearm (both groups), and FFSCA of the forearm (both groups).

Based on studies that demonstrate cold-induced reductions in strength, it is estimated that maximal strength declines ~3% per 1°C decrease in muscle temperature (Bergh & Ekblom, 1979; Holewijn & Heus, 1992; Sargeant, 1987). Interestingly, one of the original investigations on local cold exposure noted an immediate decrease in maximal strength that persisted until ~40 min postexercise and then increased ~20% above pretreatment levels; demonstrating the importance of timing (Johnson & Leider, 1977). In general, studies show no effect (Holewijn & Heus, 1992; Long & Hopkins, 2009; Thornley et al., 2003) or an increases (Mallette et al., 2021) in strength following local heat stress. One possible explanation for this heat-induced increase in strength is due to altered motor unit recruitment patterns, leading to enhanced neural drive (Mallette et al., 2021). While maximal strength appears to decline acutely, local cold stress also exerts an anti-fatigue effect with the optimal muscle temperature reported as being ~26°C (Edwards et al., 1972). A direct relationship (r -0.98) has been found between temperature and fatigue resistance during isometric exercise after pre-exercise direct application of thermal stress (-11.9-to-48°C) (Thornley et al., 2003). Furthermore, application of ice or cold packs to exercising muscle has been shown to increase the volume of work completed by ~15-26% (Bacon et al., 2012; Galoza et al., 2011; Thornley et al., 2003;

Verducci, 2000). Therefore, modulating muscle temperature has meaningful implications for training quality.

While several studies have explored the effects of heat or cold stress alone on skeletal muscle (Hyldahl et al., 2020), to our knowledge, none exist that incorporated a combined strategy as was utilized here. More specifically, existing studies typically implement heating or cooling in the postexercise period during training. Here we show that the exercising arm with alternating heating/cooling increased biceps 1RM and forearm MVC. Though cooling was applied in the postexercise period (20 min arm cold water immersion at 10°C), Yamane et al (Yamane et al., 2006) reported similar improvements in forearm isometric strength following 4-wk training at ~75% MVC. While not all studies agree (Hyldahl et al., 2020), others also report improved performance when incorporating postexercise cooling with RE training, including 35% greater dynamic strength, but not isometric, following 12-wk RE with limb immersion in cold water (10 min at 10°C) (Roberts et al., 2015). Compared to effects of cold, much less is known about heat and adaptability to RE. This is surprising given Gato et al. (Yamashita-Goto et al., 2002) demonstrated greater stretch-induced hypertrophy of L6 myotubes when passively heated compared to a "stretch-only" group nearly 2 decades ago. The few investigations that have attempted to translate these pre-clinical findings into humans show increased muscle size and isometric strength with passive heating (8 h/d, 4 d/wk for 10wk at an increased muscle temperature of ~2°C) (Goto et al., 2011) and increased isometric muscle strength (but not size) after passive heating (90 min/d, 5 d/wk for 8 wk at ~52°C) (Kim et al., 2020). While RE studies utilizing heat are sparse, two recent reports show that local heat application prior to RE training sessions(3 d/wk for 6 wk; 20 min at 75 °C) (Nakamura et al., 2019) and during/after RE training sessions (2-3 d/wk for 12 wk; limb heated to ~38°C) (Stadnyk et al., 2017) increased muscle strength and size.

Although the control arm was not directly involved in the isometric exercise training and heating and cooling stimulation, it clearly adapted as indicated by increasing upper arm strength and fatigue resistance, forearm MVC, fatigue resistance, and size. Observations such as those noted here in the control arm have been made dating back to 1894 (Scripture et al., 1894) and are generally termed "cross-education". This adaptation in a non-exercising, contralateral limb is suspected to occur via the central nervous system. Not all studies demonstrate this effect (Tesch & Karlsson, 1984), however, it has become well-accepted and our findings provide additional support (Kannus et al., 1992).

It is important to acknowledge this study is not without limitations. First, we did not include an exercise or heat/cold stress only group. While the purpose of this study was to determine if direct heat and cold combined application with exercise training resulted in improved size and performance, the approach utilized here makes it difficult to extrapolate findings to benefits beyond exercise alone. Second, we selected to assess potential changes in muscle size indirectly (i.e., FFCSA). Therefore, we can only speculate as to changes in FFCSA being due to increases in skeletal muscle size specifically. Lastly, we did not directly measure muscle temperature. It has been established that muscle temperature changes of ~1-2°C greatly impacts performance. Though a similar heat and cold application strategy was implimented here in studies that do direclty assess changes in muscle temperature, it is not possible to confirm muscle temperature was altered.

Exercise training quality is a primary factor governing adaptations to size, strength, and fatigue resistance. Therefore, identifying practical methods to optimize training strategies have implications for performance and rehabilitation. With guidance from reports on the benefits of independent heat and cold exposure to exercising muscle, our intention was to explore a novel, practical exercise training paradigm that incorporated both forms of thermal stress. Though increased performance was observed, we did not find an apparent benefit of the local heat and cold application model utilized here. Given the unexplored nature of this area, findings provided here will begin to lay the framework for future work. These studies are encouraged to examine the potential effects of timing and order of heat/cold application.

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