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Acute Beetroot Supplementation May Improve Blood Pressure But Not Exercise Economy in Female Masters Swimmers

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Abstract

It is known that beetroot supplements may improve exercise economy and blood pressure, but this has mainly been studied in males. Given that older female athletes are underrepresented in the literature, we aimed to determine if acute beetroot supplementation (BRS) improves exercise economy and blood pressure in masters female athletes (swimmers) during a treadmill exercise test. Methods: 11 participants (57.8±10.5 y) underwent 2 randomized, double-blinded trials, ingesting beetroot (BE) or placebo (PL). Salivary NO2- (sNO2-) and blood pressure (BP) were measured pre-ingestion (Base), pre-exercise (Pre), and 5 min post-exercise (Post). Oxygen consumption (VO_2) was measured during the modified Balke test until HR reached 85% of age-predicted maximum. Exercise economy (ExEc) was defined as the average relative VO_2 during min 3-4.5 of the test. sNO2- was determined using NO2- detection strips. Results: sNO2- increased from Base to Post in BE vs PL (32.5±7.0 vs 2.7±3.9% change, p = 0.001). No treatment differences existed for ExEc (BE: 15.51±0.47 vs PL: 15.71±0.53 ml·kg-1·min-1, p = 0.48). Diastolic BP was significantly lower in BE vs PL (Base: 74.6±1.7 vs 73.2±2.3, Pre: 73.6±1.8 vs 74.5±2.1, Post: 74.5±1.7 vs 76.1±2.2 mmHg, p = 0.03, treatment by time). Conclusion: Acute BRS lowered diastolic BP, but did not improve exercise economy in these trained, normotensive athletes. Further research is warranted in menopausal and post-menopausal females, including those who are hypertensive, and in other female masters athlete groups.

Keywords: older athletes, dietary nitrate, treadmill exercise

1 Introduction

Beetroot supplements are popular among athletes who seek to improve endurance exercise performance and older adults who desire to lower blood pressure. Beetroot supplements (BRS) are high in dietary nitrate (NO3-), which circulates in the plasma after ingestion; a portion of this NO3- enters the entero-salivary circulation and is concentrated in the saliva (Spiegelhalder et al., 1976). The salivary NO3- is then reduced to nitrite (NO2-) by bacteria on the surface of the tongue (Webb et al., 2008). When this NO2- is swallowed and enters the stomach, some is further reduced in the acidic environment to nitric oxide (NO), while some enter the systemic circulation, increasing circulating NO (Lundberg & Govoni, 2004). NO is a powerful signaling molecule that lowers resting blood pressure by increasing vasodilation and may reduce the oxygen cost of submaximal exercise, improving exercise performance (Jones, 2014).

The effects of BRS on exercise economy have been widely investigated, with several investigations reporting improvements (i.e., reduced oxygen cost of exercise) with BRS (Bailey et al., 2009; Larsen et al., 2007; Pinna et al., 2014; Waldron et al., 2018), while others have not found significant improvements with BRS compared to placebo (Rokkedal-Lausch et al., 2021; Wickham et al., 2019). The blood pressure-lowering effects of BRS have also been widely studied, with many investigations reporting that BRS is effective in lowering resting blood pressure (Bailey et al., 2009; Lansley et al., 2011b; Stanaway et al., 2019; Vanhatalo et al., 2010; Waldron et al., 2018; Webb et al., 2008).

Despite the plethora of research on the effects of BRS on exercise economy and on blood pressure, there are notable gaps. Firstly, most investigations have been conducted using mostly or exclusively male participants. Females, especially older female athletes, are vastly underrepresented in the currently published investigations concerning dietary NO3- supplementation (Wickham & Spriet, 2019). Therefore, studying BRS in females could lead to a better understanding of the effects of BRS in this population.

In addition, many of the studies of BRS are conducted using recreationally active participants rather than well-trained individuals (Bailey et al., 2009; Perez et al., 2019; Vanhatalo et al., 2010; Waldron et al., 2018; Wickham et al., 2019). Of the studies that focus on trained athletes, most used cyclists (Lansley et al., 2011a; Rokkedal-Lausch et al., 2021) or runners (Boorsma et al., 2014; de Castro et al., 2019). A few studies have examined BRS with swimmers (Esen et al., 2019; Pinna et al., 2014; Pospieszna et al., 2016), but the participants were generally young (average age of 20-22 yrs.) (Esen et al., 2019; Lowings et al., 2017; Pospieszna et al., 2016), or were all male (Pinna et al., 2014). To our knowledge, the effects of BRS on exercise economy and blood pressure have not been studied exclusively in female masters (defined as age 35 yrs and older) athletes, especially in those that are swimmers.

Therefore, the primary purpose of this study was to determine if acute BRS improved the oxygen cost of submaximal exercise (i.e., exercise economy, ExEc) in female masters swimmers during an incremental treadmill test. We also aimed to determine if acute BRS lowered blood pressure (BP). We hypothesized that acute BRS would improve exercise ExEc and reduce pre- and post-exercise BP compared to a placebo treatment in our population of trained female masters swimmers.

2 Methods

2.1 Experimental Design

This study used a randomized, double-blind, crossover design. Participants underwent two randomly ordered, double-blinded trials in which they ingested either 10 oz of BRS (BE) or placebo (PL) 30 min before performing a modified Balke treadmill test. Baseline BP and salivary NO2- levels were measured pre-ingestion (Base), 25 min after ingestion, which was 5 min pre-exercise (Pre), and post-exercise (Post). Oxygen consumption (VO_2) was measured every 15 sec, and HR and RPE were measured every 60 sec of the treadmill test until participants reached 85% of their APMHR. Dependent variables were salivary NO2- response, BP, HR, ExEc, RPE, and treadmill test time.
The protocol for the experimental trials is shown in Figure 1.

2.2 Participants

Eleven female masters swimmers (age 57.8±10.4 yrs.; height: 167.8±5.5 cm; body mass: 66.7±11.0 kg) enrolled in and completed the study. Each had trained consistently and competed in swimming events for at least the last year. Participants were recruited via emails to local masters swimming groups and clubs in the Minneapolis/Saint Paul, Minnesota, USA, metropolitan area. All participants provided voluntary written informed consent to participate in the study, which was approved by the Hamline University Institutional Review Board (2019-05-27ET). Prior to testing, participants were screened for any cardiorespiratory or musculoskeletal issues that would put them at greater risk of an adverse event through a health history questionnaire and a resting electrocardiogram (ECG), which was read by a cardiologist. Prior to recruitment, a power analysis was performed using G-Power 3.1.9.2 software (Dusseldorf University, Germany; (Faul et al., 2007)). The minimum number of participants needed for a two-tailed alpha level of 0.05 and desired power value of 0.80 was 10.

2.2.1 Pre-Trial Diet and Nitrate/Nitrite Washout

Participants completed a 3-day food and exercise log before the first trial and were asked to replicate the same diet and exercise schedule during the 24-hr period prior before the second trial. They were asked to avoid nitrate and nitrite-containing foods for the 24 hrs. prior to each trial, and a list of nitrate and nitrite-containing foods was provided to them at their screening session. Participants were also asked to avoid mouthwash and chewing gum for 24 hrs. prior to each trial and compliance was checked by investigators.

2.2.2 Experimental Beverages

The BE (BeetElite, Human^N Co, Austin, TX, USA) and PL ingredients were obtained in powder form and mixed in the laboratory by a laboratory member not involved in data collection. Both were mixed into 10 oz of water in an opaque sports bottle. The placebo beverage matched the BE in energy and electrolyte content and in color.

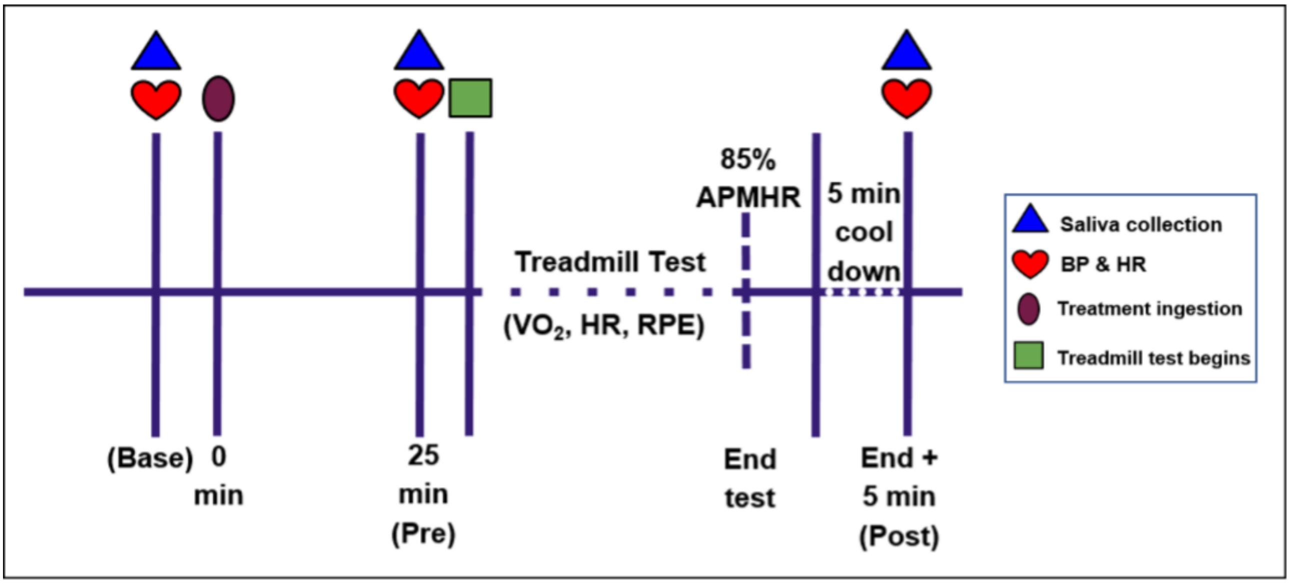

Figure 1: Experimental protocol

Notes. Participants ingested either 10 oz of beetroot supplement or placebo 30 min before performing a modified Balke treadmill test. The 3-time points (Base, Pre, and Post) for saliva sampling and seated blood pressure and heart rate measurements are shown. Peak VO_2, HR, and RPE were recorded at the end of the treadmill test.

2.3 Measurements

2.3.1 Salivary NO2- Response

The salivary NO2- response was used as an indirect indicator of the systemic NO response to the treatments. Saliva samples (0.5 mL) were taken via passive drool into a collection tube (Salimetrics, State College, PA) at each of the 3-time points (Base, Pre, Post). Changes from baseline in salivary NO2- response was determined using commercially available NO indicator strips (Nitric Oxide Indicator Strips, Human^N, Austin, TX) and a quantification and analysis protocol developed in our lab. Because the manufacturer's instructions were not sufficiently standardized for laboratory use, we previously developed a process to ensure validity and reliability of test strips across the 3-time points.

Briefly, this protocol was as follows: 2 min prior to each saliva collection, participants rinsed their mouths with a small amount of water, and the collection was taken via passive drool. A test strip was exposed to the sample for 2 sec. Images were taken at 60-sec post-collection with an iPad Mini on an image capture station (Figure 2A). Each sample test strip pad was placed between a standard (dark pink intensity) and a background reference (white pad) strip, and an image showing all 3 test strip pads was taken at each time point (Figure 2B). After each trial, the images were downloaded to a lab computer, and the color intensity of the standard, sample, and background pads in each image was analyzed using ImageJ (Schneider et al., 2012). The ImageJ results were exported into Microsoft Excel 2016 (Microsoft Corp., Redmond, WA, USA), where the background values were subtracted, and the absolute sample color intensity values were converted to percentage of the standard intensity value.

2.3.2 Blood Pressure

Blood pressure (BP) was measured manually at the 3-time points (Base, Pre, Post) using a cuff and sphygmomanometer (752M Mobile Aneroid; American Diagnostic Corporation, Hauppauge, NY, USA). Participants rested, seated, for 5 mins before BP was measured in the dominant arm. 3 mins later, BP measurement was repeated on the other arm. The highest of the 2 values was used for analysis.

2.3.3 Treadmill Testing

The modified Balke protocol was performed on a Trackmaster TMX425C treadmill (Full Vision, Newton, KS, USA) and consisted of a 2 min warm-up at 3.0 mph, then a testing portion at 3.5 mph in which the grade increased by 2% every 2 min until the participant reached 85% of their age-predicted maximum heart rate (APMHR) using the formula (HRmax= 208 - 0.7 x age) (Tanaka et al., 2001); the duration of this testing portion was recorded as the treadmill test time. Once APMHR was achieved, the incline was lowered to 0% grade and speed was reduced to 2.0 mph for a 5-minute cool down. During each trial, the laboratory temperature was maintained at approximately 21°C, and a fan was directed toward the participant to reduce thermal stress. Consistent verbal encouragement was given to all participants by the same investigators during each trial.

2.3.4 Exercise Economy

Oxygen consumption (VO_2) was continuously measured throughout the treadmill test, with values recorded every 15 sec. Participants breathed through a Hans Rudolph valve, and expired gases were directed to a mixing chamber for the analysis of oxygen and carbon dioxide (ParvoMedics TrueOne 2400, Parvo Medics, Sandy, UT, USA). Exercise economy (ExEc) was defined as the average VO_2 relative to body mass (mL·kg-1·min-1) between minutes 3 and 4.5 of the treadmill test (Losnegard et al., 2014).

2.3.5 Heart Rate

HR was recorded using a heart rate monitor (Polar Electro Oy, Kempele, Finland). HR was measured at each of the 3 time points (Base, Pre, Post), as well as every minute during the treadmill test and the cool down.

2.3.6 Rating of Perceived Exertion

RPE was assessed every 2 min during the treadmill test using a 1-10 scale, with 1 indicating no effort at all, and 10 indicating maximal effort. A color-coded chart was displayed on the treadmill control panel and its use was explained to the participants before each trial. This allowed participants to relay their RPE physically by pointing.

2.4 Statistical Analyses

ExEc, RPE, and treadmill time were analyzed using two-tailed paired t-tests. Salivary NO2- levels, SBP, DBP, and HR were analyzed with two-way (treatment x time) repeated measures ANOVA. Post hoc analysis was performed using a Bonferroni correction when significance was found. The significance level for all analyses was determined at $p \leq 0.05$. All data were expressed as mean ± SE. SPSS Version 26 software (IBM Corp., Armonk, NY) was used for all statistical analysis.

3 Results

3.1 Blood pressure

As shown in Figure 3A, no treatment differences in systolic BP were found between BE and PL (Base: 116.6 ± 1.5 vs. 115.5 ± 1.6, Pre: 115.0 ± 1.7 vs. 116.0 ± 1.7, Post: 116.5 ± 1.4 vs. 118.3 ± 1.5 mmHg, respectively, p = 0.71), although trends towards significance existed for differences by time (p = 0.059), and treatment by time (p = 0.053). Significant differences in diastolic BP Figure 3B) existed between BE and PL by time (Base: 74.6 ± 1.7 vs. 73.2 ± 2.3, Pre: 73.6 ± 1.8 vs. 74.5 ± 2.1, Post: 74.5 ± 1.7 vs. 76.1 ± 2.2 mmHg, p = 0.035) and treatment by time (p = 0.026), although treatment-only differences were not significant (p = 0.79).

3.2 Salivary NO2-

As shown in Figure 4, salivary NO2- levels, an indirect indicator of the systemic NO response, increased significantly from Base in BE (Base: 26.1% ± 3.1%, Pre: 52.0% ± 4.2%, Post 58.5% ± 6.8%), but not in PL (Base: 25.4% ±2.1%, Pre: 31.9% ± 3.7%, Post: 28.1% ± 3.7%, p = 0.001), with significant time and treatment by time effects (p = 0.000).

3.3 Exercise Economy

There were no significant differences between treatments in ExEc (BE: 15.51±0.47 vs. PL: 15.71±0.53 ml·kg-1·min-1, p = 0.48, Fig. 5A). There was also no significant difference in treadmill test time between BE and PL (BE: 15.5 ± 1.9 vs. PL: 15.4 ± 1.8 min, p = 0.92, Fig. 5B).

3.4 Heart Rate

The heart rate response to acute BRS did not differ between BE and PL (Base: 62.0 ± 2.4 vs 63.6 ± 2.1, Pre: 63.2 ± 2.5 vs 65.4 ± 2.2, and Post: 72.6 ± 3.2 vs 74.6 ± 2.4 bpm, respectively, p = 0.12), although the time effect was significant as expected (p = 0.00). The treatment by time interaction was not significant (p = 0.86).

3.5 Rating of Perceived Exertion

Peak RPE was not significantly different between treatments (BE: 6.2 ± 0.5 vs. PL: 6.5 ± 0.5, p = 0.25).

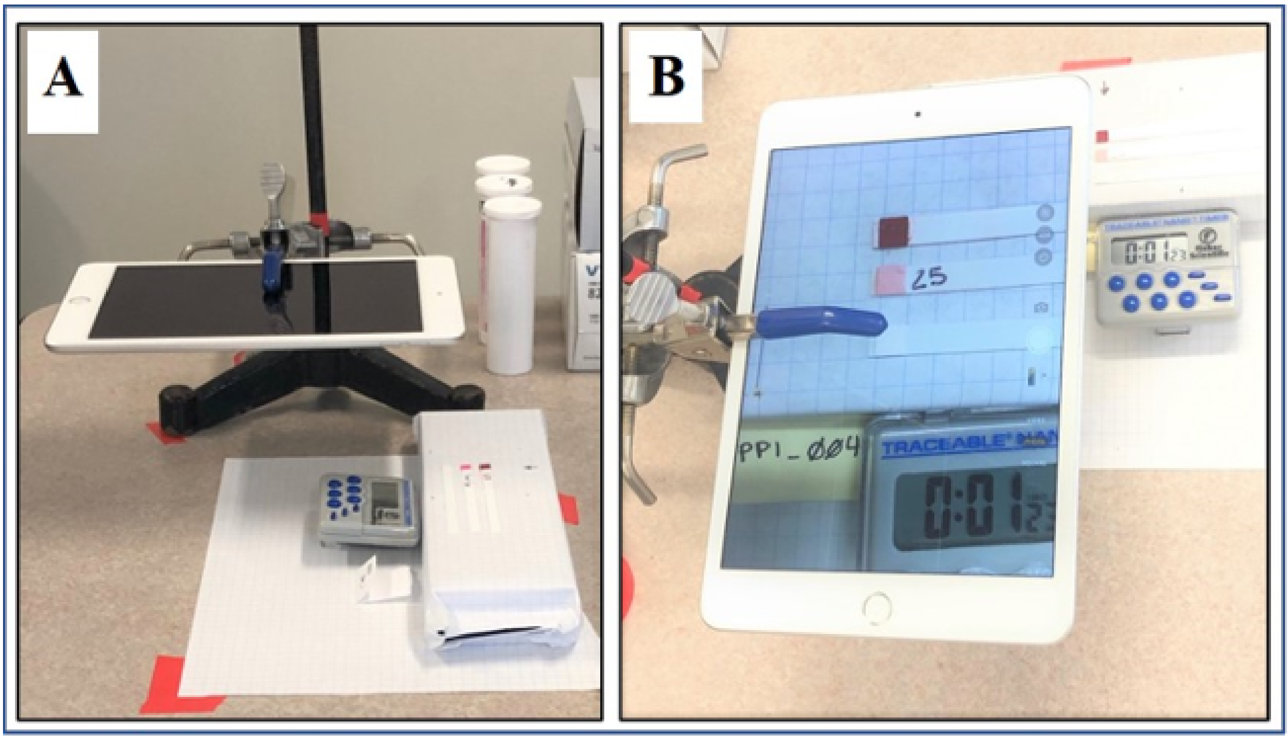

Figure 2: Image capture system for determination of the salivary nitrite response

Notes. A. Side view of the image capture station. B. Example of an image on the iPad Mini screen, as is captured during an experimental trial. The standard is the top (darkest) pad, the reference pad is the bottom, and the test strip (labeled) is in the middle. Quantification and analysis were performed post-trial using ImageJ.

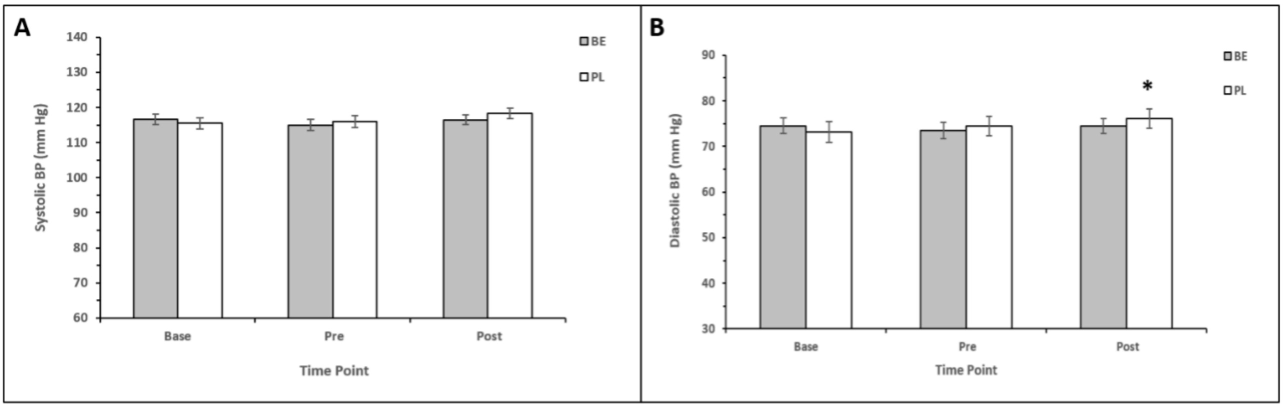

Figure 3: Systolic (A) and diastolic (B) blood pressure was measured at 3 time points during each trial (Base, Pre, and Post).

Notes. A. Systolic blood pressure. B. Diastolic blood pressure (*treatment by time, $p = 0.026$;). A significant time effect was present for diastolic blood pressure ($p = 0.035$), whereas there was a trend toward a significant time effect for systolic blood pressure ($p = 0.059$). The systolic blood pressure treatment by time interaction also trended toward significance at $p = 0.053$. Values are mean ± SE.

4 Discussion

The primary purpose of this study was to determine if acute beetroot supplementation (BRS) lowered the oxygen cost of exercise (improved ExEc) in female masters swimmers during an incremental submaximal treadmill test. We also aimed to determine if acute BRS lowered BP in our study group. The most noteworthy finding of this study was that although ExEc did not differ

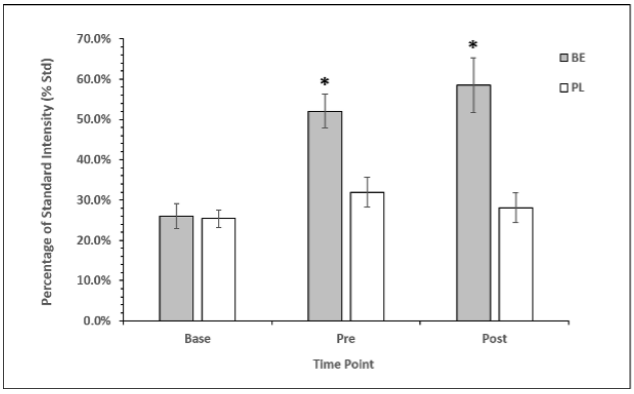

Figure 4: Salivary nitrite response at 3-time points during each trial (Base, Pre, and Post).

Note. Significant effects were found for treatment (*p = 0.012), time (p = 0.000), and treatment by time (p = 0.001). Values are mean ± SE.

between the BRS and placebo treatments, post-exercise diastolic BP was significantly lower with the BRS treatment (BE) compared to placebo (PL). To our knowledge, this was the first investigation to examine the effects of BRS on ExEc and BP in female masters athletes (i.e., over the age of 35 yrs.).

In the present study, BRS did not improve ExEc, which is in disagreement with several other studies that reported either improved ExEc (Muggeridge et al., 2013; Vanhatalo et al., 2010) or improved power output at the same VO_2 (Lansley et al., 2011a) with acute BRS compared to placebo. However, these 3 previous investigations used either exclusively or mostly male participants. Our finding of no improvement in ExEc with BRS agrees with that of Wickham et al. (Wickham et al., 2019), who also used a submaximal exercise protocol with an exclusively female study population (n=12), although the participants were recreationally active and young (average age of 23 yrs.). Considering that both Wickham et al. (Wickham et al., 2019) and the present study found no difference in ExEc with BRS, sex differences should be considered as a possible explanation, at least in part, for the conflicting findings. However, it is likely that additional methodological differences between studies underlie the conflicting findings across investigations, as is discussed below.

The secondary aim of the present study was to determine the effects of BRS on resting and post-exercise BP in our study participants. Although there was no treatment difference at baseline or pre-exercise, post-exercise diastolic BP was significantly lower with BE compared to PL. This contrasts with that of Amaral and colleagues (2019), who investigated the effects of acute BRS on post-exercise BP in 13 female participants (average age 58 yrs.) and reported no difference in post-exercise BP between treatments. In the present study, 7 of our participants were postmenopausal and 4 were peri-menopausal, but were all healthy, trained individuals, whereas Amaral et al.'s participants were all post-menopausal, but were untrained and hypertensive. It is unclear why diastolic BP was reduced in our normotensive population but not in the hypertensive population in Amaral et al. (Amaral et al., 2019). It is important to study females who are peri-menopausal, menopausal, and post-menopausal, since menopause is associated with a 2-fold greater risk of hypertension (Barton & Meyer, 2009); finding ways to reduce risk of developing hypertension and reducing overall cardiovascular disease risk is of great public health importance for this significant portion of the population.

Stanaway and colleagues (Stanaway et al., 2019) investigated differences in the BP response to BRS in older (age 56 yrs.) vs younger (age 25 yrs.) male and female adults, and found that while resting systolic and diastolic BP was decreased to the same extent in both age groups with BRS compared to placebo, the decrease in diastolic BP was significantly greater in the older compared to the younger group. In the present study, the treatment difference in systolic BP approached significance at p = 0.053 (treatment by time), while diastolic BP was significantly lowered. Taken together, the findings of Stanaway et al. (2019) and those of the present study suggest that BRS may benefit older individuals to a greater extent for blood pressure reduction purposes, particularly in lowering diastolic BP.

The methodological differences that likely underlie the conflicting findings among studies of BRS and exercise, BP, and ExEc include differences in the populations of interest and participant characteristics (e.g., sex, training status, and age), and the timing and frequency of supplement ingestion. However, perhaps the most important difference between studies of acute BRS is the NO3- content (i.e., dose) of the supplements given. Gallardo and Coggan (2018) suggested that the minimal effective NO3- dose to impact exercise efficiency is at least 5.0 mmol; they also analyzed the nitrate content of several commercially available BRS, and determined that the BRS used in the present study (BeetElite, Human^N Co., Austin, TX, USA) contained only 2.16 ± 0.28 mmol NO3-. A recent review by Macuh and Knep (2021) suggested that BRS is an effective ergogenic aid when taken in the dose range of 5 to 16.8 mmol, 2 to 3 hours before ex-

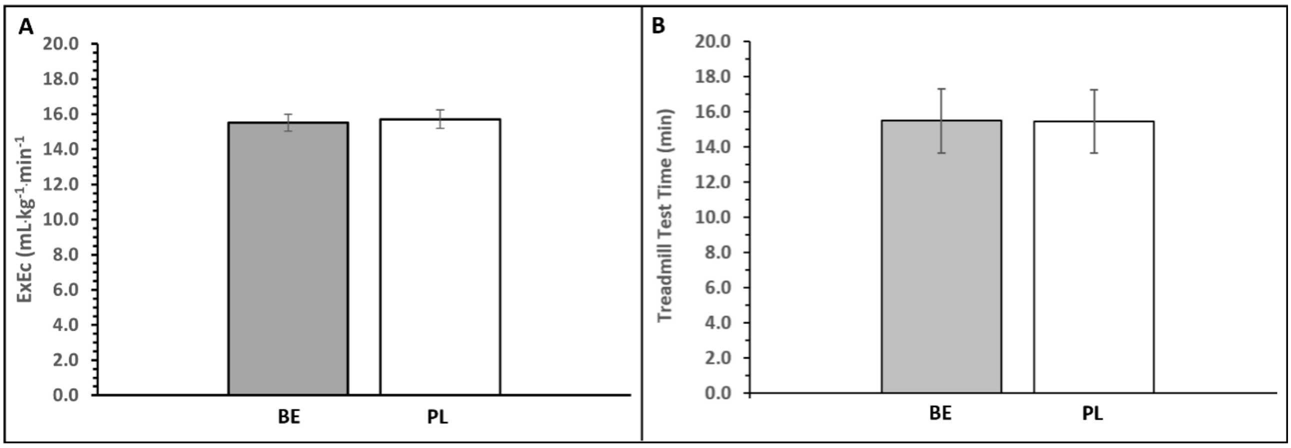

Figure 5: Treadmill test time and peak oxygen consumption (VO_2).

Note. (A) Total treadmill time; test was terminated, and the end time recorded, when participants reached 85% of age-predicted maximum heart rate. No difference was found between treatments (p = 0.915. (B) Peak VO_2 during the treadmill test for each treatment; no difference was found between treatments (p = 0.314). Values are mean ± SE.

ercise. Lorenzo Calvo and colleagues (2020) reported a similar finding based on their systematic review, concluding that the effective range is 6 to 12.4 mmol taken 2 to 3 hours before exercise; however, they reported that the effects of BRS on ExEc are unclear, even when taken within the effective range. Therefore, our findings of no difference between BRS and placebo are likely due to the minimal NO3- content and timing of dosage. However, NO3- content differences do not solely explain differences in findings between studies. Wickham and colleagues (2019) found no differences in ExEc despite their BRS containing 26 mmol, and Amaral et al. (2019) reported no difference in post-exercise BP, despite administering a relatively high dosage BRS (20.78 mmol).

Another factor that may explain differences in findings is the timing of supplement administration. Most of the acute studies provide BRS 2 to 3 hours prior to exercise and/or resting BP measurement (Amaral et al., 2019; Lansley et al., 2011a; Muggeridge et al., 2013; Stanaway et al., 2019; Vanhatalo et al., 2010; Wickham et al., 2019). It has been reported that while plasma NO3- concentrations rise rapidly within 30 min of BRS ingestion and may peak as early as 1.5 h post-ingestion (Webb et al., 2008), the peak plasma concentration most likely occurs closer to 3 h after ingesting a BRS containing 4 mmol or greater NO3- (Kapil et al., 2010). Therefore, the timing of our dose in the present study likely contributed to the findings of no difference in ExEc.

There are limitations to the present study. First, it is possible that starting our treadmill protocol at 30-min post-supplementation may have been too soon to detect an effect on oxygen consumption. Second, we did not assess plasma nitrite and nitrate levels, which would have given a more accurate picture of the plasma response to the treatments. Third, we used a treadmill exercise test in trained swimmers rather than a swimming test; however, this was done due to the significant challenges associated with collecting VO_2 data during a swimming test. Lastly, the dietary nitrate content of the chosen supplement may have simply been too low to elicit a physiological effect on oxygen consumption.

5 Conclusion

Acute beetroot supplementation did not improve exercise economy in this population of trained female masters athletes, although it did lower diastolic blood pressure in this healthy, normotensive group. Further research is warranted in menopausal and post-menopausal females, including those who are hypertensive, and in other female masters athlete groups.

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Conflict of Interest

The Human^N Co., Austin, TX, provided the beetroot supplement for the study.

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Acute Effects of Different Number of Sets and Non-Equalized Volume on Muscle Thickness, Peak Force, and Physical Performance in Recreationally-Trained Participants

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Abstract

This study aimed to measure the acute effects of resistance training (RT) protocols with a different number of sets and non-equalized volume on muscle thickness, peak force, and physical performance in recreationally trained participants. Fifteen participants performed the unilateral biceps curl exercise in four different RT protocols (G_4: 4 sets of 10RM, G_8: 8 sets of 10RM, G_{12}: 12 sets of 10RM, and G_{16}: 16 sets of 10RM). The average number of repetitions (ANR), the total number of repetitions (TNR), time under tension (TUT), muscle thickness (MT), peak force (PF), and rating of perceived exertion (sRPE) were measured pre-test and post-test. ANOVAs were used to test differences between all dependent variables. For ANR, there were differences between G_4xG_8, G_4xG_{12}, and G_4xG_{16}. For TNR, there were differences between all RT protocols. For TUT, there were differences between the first and last set for all RT protocols and between RT protocols for the last set. For PF, there were differences between the pre- and post-test for all RT protocols and between RT protocols for Post-0 (G_4 x G_{12}, G_4 x G_{16}, and G_8 x G_{16}). For MT, there were differences between the pre- and post-test for all RT protocols. In conclusion, G_8, G_{12}, and G_{16} showed lower ANR than G_4, TNR increased with increasing sets, and TUT increased in all RT protocols. PF decreased with an increasing number of sets, and all RT protocols increased MT. The sRPE was similar to RT protocols.

Keywords: neuromuscular fatigue, muscular performance, skeletal muscle

1 Introduction

Resistance training (RT) is an effective tool to induce acute muscle responses (e.g., cell swelling and neuromuscular fatigue) and chronic muscle adaptations (e.g., muscle hypertrophy, endurance, power, or strength) (Scarpelli et al., 2022). The manipulation of the acute RT variables, such as the total number of sets per RT session and muscle group is associated with increases in strength and cross-sectional area (Mangine et al., 2015); however, the upper and lower limit of sets is under debate in the scientific literature (Aube et al., 2020; Barbalho et al., 2020; Figueiredo et al., 2018; Krieger, 2010; Schoenfeld et al., 2019; Schoenfeld et al., 2016; Smilios et al., 2003). Most studies have assessed the weekly number of sets in chronic designs; however, understanding the acute responses from an RT session is fundamental to determining the effective volume and then the weekly sets. To the author's knowledge, no study has been conducted to assess the effective number of sets per RT session on mechanical and metabolic stress. Understanding the limits of the number of sets is essential to increase efficiency in prescribing and controlling each RT session, optimizing the time for each RT session, and inducing favorable levels of metabolic stress and mechanical tension (Lim et al., 2022; Marchetti, 2022; Medicine, 2021; Schoenfeld, 2013; Schoenfeld & Contreras, 2014).

The level of cell swelling can indirectly characterize metabolic stress after an RT exercise or workout. After an RT session, metabolic stress products such as growth hormone, lactate, and reactive oxygen species are produced simultaneously. They are important in activating the mammalian target of the rapamycin pathway (mTOR) and muscle protein synthesis (Hirono et al., 2020). Therefore, cell swelling immediately after an RT session may be involved in the hypertrophic metabolic stress response, resulting from increased phosphocreatine, increased lactate production and nitric oxide, accumulation of hydrogen ions, inorganic phosphate, and increase in the production of growth hormone and cortisol (Hirono et al., 2020). Specific ultrasound images can evaluate acute cell swelling via muscle thickness (MT) based on the distance from the subcutaneous adipose tissue muscle to the muscle-bone interface. MT is an image evaluation technique widely used in RT to assess the degree of cell swelling due to the workout performed (Wong et al., 2020; Yitzchaki et al., 2019). In combination with MT, the force production measured after an RT session complements the metabolic analysis as it indirectly indicates an increase in the production of lactate and hydrogen ions (neuromuscular fatigue) and may influence water uptake into muscle cells according to cell permeability (Behrens et al., 2023; Chen et al., 1996; Hirono et al., 2020; Schoenfeld & Contreras, 2014; Sjøgaard et al., 1985; Usher-Smith et al., 2009). Additionally, mechanical tension induced by an RT session causes mechanochemically transduced molecular and cellular responses in myofibers and satellite cells (Lim et al., 2022; Schoenfeld, 2010), which are fundamental to inducing acute responses and chronic adaptations such as muscle growth (Lim et al., 2022).

Additionally, studies have reported similar chronic adaptations when the total volume was equated (Figueiredo et al., 2018; Schoenfeld et al., 2014); however, in many cases, the total volume cannot be equalized for practical training reasons. So, in the present study, the total volume was not equalized, aiming to assess the acute responses between RT protocols with a different number of sets but the same external load (10RM). This study can help practitioners and strength athletes who aim to plan their training volume but do not necessarily manage to equalize the total volume. To the author's knowledge, no study has been conducted to assess the acute metabolic stress and mechanical tension induced by a different number of sets without equalizing volume in recreationally trained participants. This study intended to assess the difference between RT protocols and provide useful information to practitioners regarding the effects of more or fewer sets in an RT session. Therefore, the main purpose of this study was to measure the acute effects of RT protocols with a different number of sets and non-equalized volume on muscle thickness, peak force, and physical performance in recreationally-trained participants. The first hypothesis was that more sets per RT protocol will induce a greater reduction in the average number of repetitions and increase the time under tension and the total number of repetitions; however, sRPE will remain constant for all RT protocols. The second hypothesis considers that more sets per RT protocol will induce a greater reduction in peak force and increase muscle thickness (Damas et al., 2018; Schoenfeld, 2010, 2013; Schoenfeld & Contreras, 2014; Schoenfeld et al., 2016). The results of this study will help coaches and trainers understand and prescribe better acute RT sessions based on the number of sets, avoiding excessive volume.

2 Methods

2.1 Participants

A pilot study determined the number of participants conducted previously based on an effect size difference of 0.95, a significance level of 5%, and a power of 80% derived from the muscle thickness of individuals with the same characteristics used in the present study. Fifteen resistance-trained men were assigned to this study [age 25.8 ± 2.5 years, total body mass 84.7 ± 11.8 kg, height 176.7 ± 4.9 cm, dominant biceps curl exercise (10RM) 12.3 ± 2.9 kg, non-dominant biceps curl exercise (10RM) 11.5 ± 2.6 kg]. All participants were familiar with hypertrophy-type training and had regularly engaged in an RT routine for more than a year. Additionally, they were familiar with the standing unilateral biceps curl exercise. They had 3±1 years of resistance training experience (at least 3 times a week), with no previous surgery or history of injury with residual symptoms (pain) in the upper limbs or spine within the last year. The Institutional Review Board (IRB) approved this study (00001788/2018). The participants were informed of the risks and benefits of the study before any data collection and then read and signed an institutionally approved informed consent document.

2.2 Procedures

This study used a randomized and counterbalanced design. Participants attended three laboratory sessions and refrained from performing upper-body exercises other than activities of daily living for at least 48 hours before testing. A within-participant approach was used in which each participant performed all RT protocols. Each RT protocol was performed unilaterally, and all sets were performed until concentric muscular failure (RM). The RT protocols were defined as follows: G_4: 4 sets of 10RM, G_8: 8 sets of 10RM, G_{12}: 12 sets of 10RM, and G_{16}: 16 sets of 10RM.

For the first session, participants were asked to identify their preferred arm for writing, which was considered their dominant arm (Maulder & Cronin, 2005). Then, anthropometric data (height, weight, and upper limb length) were evaluated. Next, all participants performed a familiarization and specific warm-up for the unilateral biceps curl exercise. The warm-up followed the following procedure: 1 set of 15 repetitions without external load, followed by 1 set of 10 repetitions with 5kg for each exercise, and 5-minute rest intervals were given between sets. To perform the unilateral biceps curl exercise, all participants stood before the cable pulley machine with a supinated grip on a handle. Any trunk movement was avoided during the protocols by the researcher in charge. They lifted the weight stack from complete elbow extension to complete elbow flexion (concentric phase) and then returned to a full elbow extension (eccentric phase). Then, a 10RM (repetitions maximum) testing was applied to both upper limbs in random order. The 10RM testing was based on the National Strength and Conditioning Association (NSCA) guidelines to determine individual initial training loads (Haff & Triplett, 2016). Attempts were performed to progressively increase the external loads until they reached the maximal capacity to perform 10RM with the correct technique. The movement velocity was self-selected.

For the second and third sessions, the participant's arms were randomly allocated within one specific RT protocol and sequence (RT protocol vs. dominant or non-dominant arm). Each participant performed two RT protocols per session, one for each arm. A specific warm-up (unilateral biceps curl exercise) was conducted during each session with 10 repetitions at 50% of their 10RM testing load. Then, as a pre-test, an ultrasound imaging of the elbow flexors was carried out followed by the maximal voluntary isometric force testing at 90 degrees of elbow flexion. Then, participants performed one of four RT protocols in random order (G_4: 4 sets of 10RM/2-min rest, G_8: 8 sets of 10RM/2-min rest, G_{12}: 12 sets of 10RM/2-min rest, and G_{16}: 16 sets of 10RM/2-min rest). After each RT protocol, the ultrasound image of the elbow flexors and the maximal voluntary isometric force were retested immediately after (post-0), 15-min after (post-15), and 30-min after (post-30) the end of each session (Aleais et al., 2022; Marchetti et al., 2020; Smith et al., 2021). All participants reported a rating of perceived exertion (RPE) 30-min after each RT protocol and session. The cadence (velocity) was self-selected. In the same session, 60-min after the first RT protocol with one arm, all measures were carried out on the contralateral arm and the participants performed another RT protocol. All four RT protocols were performed at the end of the two sessions, with two RT protocols for each arm. So, two RT protocols were performed in the same session because there was no influence between arms for all variables analyzed as observed in the pilot study and other studies carried out by the same laboratory (Marchetti et al., 2020). All tests were directly supervised by a research assistant (CSCS certified) to ensure proper performance and correct technique. All participants received similar verbal encouragement during all RT protocols, and all measures were performed at the same hour of the day (between 1 PM and 4 PM) by the same researcher.

2.3 Measurements

2.3.1 Total Number of Repetitions (TNR)

The TNR was defined by the sum of the number of repetitions in each set for each RT protocol.

2.3.2 Average Number of Repetitions (ANR)

The ANR was calculated by dividing TNR per number of sets for each RT protocol.

2.3.3 Time Under Tension (TUT)

A chronometer measured the TUT during each set for all RT protocols. Then, to define the TUT, the set duration in seconds was divided by the maximal number of repetitions. TUT was calculated for the first and last set for further analysis.

2.3.4 Session Rating of Perceived Exertion (sRPE)

The session RPE was assessed with a CR-10 scale using the recommendations of Sweet et al., (Sweet et al., 2004). Participants were asked to use an arbitrary unit (A.U.) on the scale to rate their overall effort after all RT protocols. A rating of 0 was associated with no effort, and a rating of 10 was associated with maximal effort and the most stressful exercise ever performed. All participants answered the following question based on CR-10 scale: "How was your workout?" The sRPE was asked 15-min after the end of each RT protocol.

2.3.5 Peak Force (PF)

The PF was measured by a digital load cell acquisition system (FM-204-1000K, Shenzhen Aermanda Technology Co. Ltd., Shenzhen, Guangdong, China / Capacity: 1000Kgf / Resolution: 0.01kgf). To perform the maximal isometric force testing, all participants stood before the cable-pulley machine with a supinated grip on a handle. All participants performed 3 maximal voluntary isometric contractions (MVIC) at 90 degrees of elbow flexion before (pre-test), immediately after (post-0), 15-min after (post-15), and 30-min (post-30) each RT protocol (Marchetti et al., 2020; Smith et al., 2021). Each MVIC was performed for 5-sec and 10-sec rest intervals. The peak force (PF) of each MVIC was defined, and the average of the 3 MVICs was used for further analysis. The test-retest ICC (PF) was 0.95.

2.3.6 Muscle Thickness (MT)

Ultrasound imaging was used to obtain measurements of MT. A trained technician performed all testing using an ultrasound imaging portable unit (Hitachi Noblus; Hitachi Medical Corporation, Tokyo, Japan). Following a generous application of a water-soluble transmission gel (Cskin, Medics Medical Products LLC., NY, USA) to the measured site, a 7.5-MHz linear array probe (L55 Probe) was placed perpendicular to the tissue interface without depressing the skin. Equipment settings were optimized for image quality according to the manufacturer's user manual and held constant in all sessions. When the quality of the image was deemed to be satisfactory, the image was saved to the hard drive. The MT dimensions were obtained by measuring the distance from the subcutaneous adipose tissue–muscle interface to the muscle-bone interface per methods (Abe et al., 2014). Measurements were taken on both sides of the body at the elbow flexors. The upper arm measurements were conducted while participants were in a standing position. For the elbow flexors, measurements were taken at 60% distal between the humerus's lateral epicondyle and the scapula's acromion process. To maintain consistency between pre- and post-test, each site was marked with ink. To further ensure the accuracy of measurements, at least 3 images were obtained for each side. A fourth image was obtained and averaged if measurements were more than 1mm from one another. MT was measured before (pre-test), immediately after (post-0), 15-min after (post-15), and 30-min (post-30) each RT protocol. The test-retest ICC (MT) was 0.96-0.98, and the intra-rater reliability was 0.96-0.97.

2.4 Statistical Analyses

The normality and homogeneity of variances were confirmed by the Shapiro-Wilk and Levene's tests, respectively. The mean, standard deviation (SD), and delta percentage (Δ%) were calculated. An independent sample t-test was used to compare the maximal intensity (10RM) between arms (dominant vs. non-dominant). One-way ANOVAs were used to test differences between RT protocols for ANR and sRPE. Repeated measures ANOVA (4x2) was used to test differences between RT protocols (G_4, G_8, G_{12}, and G_{16}) and time (first set and last set) for TUT. Repeated measures ANOVA (4x4) were used to test differences between RT protocols (G_4, G_8, G_{12}, and G_{16}) and time (pre-test, post-0, post-15, and post-30) for MT and PF. Post-hoc comparisons were performed with the Bonferroni test when necessary. Furthermore, the magnitudes of the difference were examined using the standardized difference based on Cohen's d units using effect sizes (d) (14). The d results were qualitatively interpreted using the following thresholds: <0.35 - trivial; 0.35-0.8 - small; 0.8-1.5 - moderate; >1.5 - large for recreationally trained (Cohen, 1988). An alpha of 5% was used to determine statistical significance.

3 Results

For the 10RM testing, there was no significant difference between dominant and non-dominant arms (12.3 ± 2.9 kg x 11.5 ± 2.6 kg, respectively, Δ%=6.5, p>0.05).

For the average number of repetitions (ANR) (Figure 1a), there were observed statistical differences between RT protocols: G_4 x G_8 (p=0.030, d=1.17 (moderate), and Δ%=18.3), G_4 x G_{12} (p<0.001, d=2.26 (large), and Δ%=30.5), G_4 x G_{16} (p<0.001, d=2.13 (large), and Δ%=31.7). The total number of repetitions (TNR) (Figure 1b), there were observed statistical differences between RT protocols: G_4 x G_8 (p=0.001, d=2.39 (large), and Δ%=39.6), G_4 x G_{12} (p<0.001, d=3.58 (large), and Δ%=53.3), G_4 x G_{16} (p<0.001, d=3.50 (large), and Δ%=63.7), G_8 x G_{12} (p=0.030, d=1.12 (moderate), and Δ%=22.7), G_8 x G_{16} (p<0.001, d=1.97 (large), and Δ%=39.9), G_{12} x G_{16} (p<0.001, d=1.06 (moderate), and Δ%=22.3).

For time under tension (TUT) (Figure 1c), there was a significant main effect for RT protocol (p<0.001) and time (p<0.001). There was a significant interaction between RT protocol and time (p=0.035). There were significant differences between the first and last set for G_4 (p<0.001, d=2.10 (large), Δ%=32.2), G_8 (p<0.001, d=2.60 (large), Δ%=41.2), G_{12} (p=0.008, d=1.41 (large), Δ%=20.8), and G_{16} (p<0.001, d=2.16 (large), Δ%=43.2). There were significant differences between RT protocols for the last set: G_4 x G_{12} (p=0.003, d=1.68 (large), Δ%=25.0), G_8 x G_{12} (p=0.010, d=1.85 (large), Δ%=29.4), G_{12} x G_{16} (p=0.020, d=1.76 (large) Δ%=8.1). For Session RPE (sRPE), there was observed no statistical difference between RT protocols: G_4 (8.3±1.5A.U.), G_8 (9.0±1.0A.U.), G_{12} (9.1±1.0A.U.), and G_{16} (9.4±1.1A.U.).

For Peak Force (PF) (Figure 2a), there were significant main effects for RT protocol (p<0.001) and time (p<0.001). There was a significant interaction between RT protocol and time (p<0.001). There were observed statistical differences for RT protocols: G_4: Pre-test x Post-0 (p<0.001, d=0.89 (moderate), and Δ%=19.4), Pre-test x Post-30 (p=0.001, d=0.45 (small), and Δ%=10.3); G_8: Pre-test x Post-0 (p<0.001, d=0.95 (moderate), and Δ%=22.9), and Pre-test x Post-15 (p=0.008, d=0.93 (moderate), and Δ%=11); G_{12}: Pre-test x Post-0 (p<0.001, d=1.32 (moderate), and Δ%=30.7), Pre-test x Post-15 (p=0.014, d=0.71 (small), and Δ%=17.7); G_{16}: Pre-test x Post-0 (p<0.001, d=2.21 (large), and Δ%=40.0), Pre-test x Post-15 (p=0.001, d=1.03 (moderate), and Δ%=20.7), and Pre-test x Post-30 (p=0.001, d=0.93 (moderate), and Δ%=18.8). There were observed statistical differences for Post-0 between RT protocols: G_4 x G_{12} (p=0.026, d=0.81 (moderate), and Δ%=18.8), and G_4 x G_{16} (p=0.003, d=1.45 (moderate), and Δ%=29.0), and G_8 x G_{16} (p=0.050, d=0.95 (moderate), and Δ%=21.3).

For muscle thickness (MT) (Figure 2b), there was a significant main effect only for time (p=0.015). There was no significant interaction between RT protocol and time (p=0.053). There were observed statistical differences for RT protocols: G_4: Pre-test x Post-0 (p<0.001, d=1.42 (moderate), and Δ%=12.5), Pre-test x Post-15 (p=0.001, d=0.81 (moderate), and Δ%=8.1), and Pre-test x Post-30 (p=0.007, d=0.57 (small), and Δ%=5.8); G_8: Pre-test x Post-0 (p<0.001, d=1.63 (large), and Δ%=13.1), and Pre-test x Post-15 (p<0.001, d=1.06 (moderate), and Δ%=10.2); G_{12}: Pre-test x Post-0 (p<0.001, d=1.62 (large), and Δ%=14.3), Pre-test x Post-15 (p<0.001, d=1.12 (moderate), and Δ%=11.4); and Pre-test x Post-30 (p<0.001, d=0.82 (moderate), Δ%=8.2); G_{16}: Pre-test x Post-0 (p<0.001, d=1.47 (moderate), and Δ%=14.7), Pre-test x Post-15 (p<0.001, d=1.15 (moderate), and Δ%=11.8), and Pre-test x Post-30 (p<0.001, d=0.90 (moderate), and Δ%=9.95).

4 Discussion

This study aimed to evaluate the acute effects of RT protocols with a different number of sets and non-equalized volume on muscle thickness, peak force, and physical performance in recreationally-trained participants. The main findings include: 1) RT protocols (G_8, G_{12}, and G_{16}) presented a similar average number of repetitions (ANR); 2) TNR increased with an increasing number of sets; 3) TUT increased between the first and last set for all RT protocols; 4) G_{12} presented a greater increase in TUT compared to G_4, G_8, and G_{16}; 5) sRPE was similar between RT protocols; 6) The increase in the number of sets induced greater PF reduction; 7) All RT protocols induced similar increases in MT.

Regarding the acute variables analyzed (MNR, ANR, and TUT), the results of this study showed that the TNR increased with an increasing number of sets (G_{16}>G_{12}>G_8>G_4); however, the ANR was similar between RT protocols (G_8, G_{12}, and G_{16}) with exception of G_4. The TUT increased between the first and last set for all RT protocols, however, G_{12} presented a greater increase in TUT compared to G_4, G_8, and G_{16}. It was hypothesized that more sets per RT protocol will induce a greater reduction in ANR and increase in TUT and TNR; the results of this study partially corroborated the hypothesis because ANR was not affected by the number of sets in each RT protocol with the exception of G_4.

It is well known that the total number of sets and repetitions associated with the external load are important components of the RT program to induce acute responses and, possibly, chronic adap-

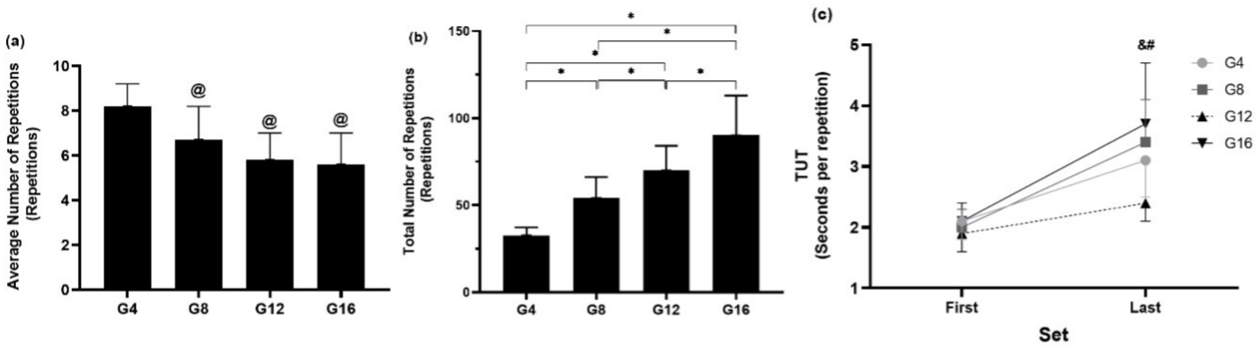

Figure 1: Mean ± standard deviation of (a) the average number of repetitions, (b) the total number of repetitions, and (b) time under tension for all RT protocols.

Note: @Significant difference with G_4, $p<0.05$. *Significant difference between RT protocols, $p<0.05$. &Significant difference between first and last set for all RT protocols, $p<0.001$. #Significant difference between G_{12} vs. G_4, G_8, G_{16}, $p<0.001$.

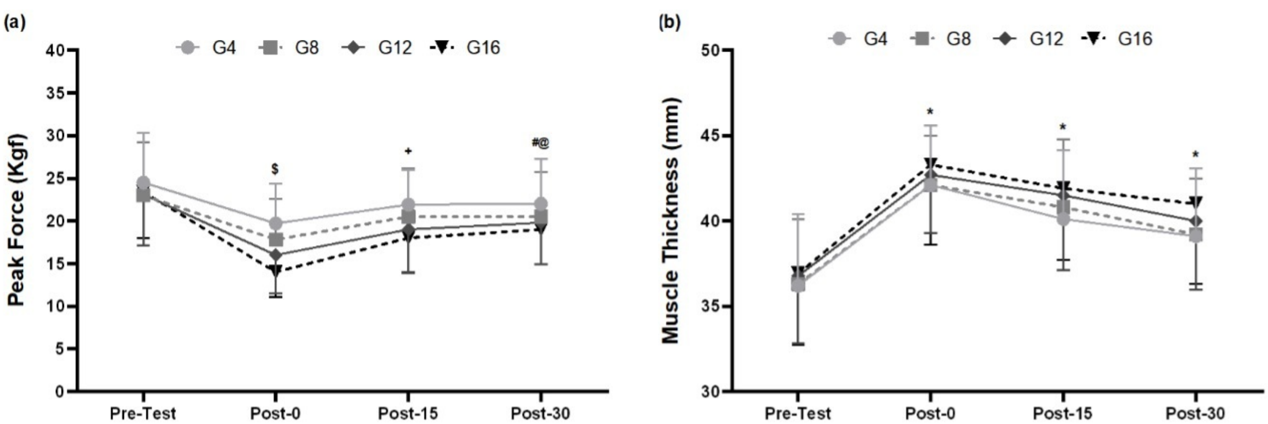

Figure 2: Mean ± standard deviation of (a) peak force and (b) muscle thickness of elbow flexors for all RT protocols

Note: $Significant difference with Pre-test, $p<0.001$. +Significant difference with pre-test for G_8, G_{12}, and G_{16}, $p<0.05$. #Significant difference with pre-test for G_4 and G_{16}, $p<0.001$. @Significant difference between G_4 x G_{12}, G_4 x G_{16}, G_8 x G_{16}, $p<0.001$. *Significant difference with Pre-test, $p<0.001$.

tations such as hypertrophy. In this study, the intensity was defined by 10RM and was kept constant during all sets and RT protocols, therefore, all variations in the acute variables were related to RT volume represented by the TNR, ANR, and TUT. In this study, the TNR for G_{16} presented the highest value when compared to G_{12}, G_8, and G_4 (22.3%, 39.9%, and 63.7%, respectively). However, the TUT for G_{12} presented the highest variation between pre- and post-test when compared to G_{16}, G_8, and G_4 (8.1%, 29.4, and 25%, respectively), representing a greater time in contraction for G_{12}. TUT has been shown to alter neurophysiological, hormonal, and metabolic responses (Burd et al., 2012; Cintineo et al., 2018; Lacerda et al., 2016; Marchetti & Lopes, 2018) and could interfere with the metabolic stress induced by each RT protocol. Extrapolating these results to chronic adaptations, TUT ranging from 0.5- to 8-sec seems to maximize muscle hypertrophy (Schoenfeld et al., 2015). So, TNR, ANR, and TUT were affected by the number of sets and it is known that high volumes might influence the dose-response relationship resulting in additional improvements in muscle mass (Schoenfeld et al., 2016). Finally, the ANR was similar between G_{16}, G_{12}, and G_8 (5.6 repetitions, 5.8 repetitions, and 6.7 repetitions, respectively).

It is well known that different RT protocols have been shown to induce different acute cell swelling, the extent of which relies on the type of exercise, level of fatigue, volume, and intensity (Schoenfeld, 2013). RT exercises with momentary muscle failure reduce the intramuscular ATP and CP levels (and Pi, ADP, and AMP accumulation) and increase the glycolytic flux (production of H+ leads to metabolite accumulation), hypoxia (via muscle contraction), and venous pooling leading to cell swelling (Chen et al., 1996; Schoenfeld & Contreras, 2014; Sjøgaard et al., 1985; Usher-Smith et al., 2009). In this study, both neuromuscular fatigue and cell swelling were assessed via PF and MT, respectively.

The peak force (PF) was measured before and after (0-min, 15-min, and 30-min) aiming to determine the level of neuromuscular fatigue induced by each RT protocol. Neuromuscular fatigue is defined as a reduction in maximal force or power production in response to contractile activity (Behrens et al., 2023). Considering the increase in the number of sets in each RT protocol, it was hypothesized that more sets per RT protocol will induce a greater reduction in PF and the results of this study partially corroborate the main hypothesis. The reduction in PF was different for all RT protocols immediately after (post-0) the training and with protocols with more sets inducing more neuromuscular fatigue [G_{16} (40%) > G_{12} (30.7%) > G_8 (22.9%) < G_{16} (19.4%)].

Ultrasound images can evaluate acute cell swelling via muscle thickness (MT) which is based on defining the distance from the subcutaneous adipose tissue-muscle to muscle-bone interface for a specific muscle (Abe et al., 2014). In the present study, MT was used to measure acute cell swelling before and after (0-min, 15-min, and 30-min) all RT protocols. It was hypothesized that RT protocols with more sets per RT session will induce a greater increase in the MT response, however, the results did not corroborate the main hypothesis. All RT protocols showed a similar increase in MT immediately after training (post-0) and MT did not return to the baseline (pre-test) after 30-min rest for all RT protocols. However, it was observed that RT protocols with more sets induced small and non-significant statistical increases in MT [G_4 (12.5%) < G_8 (13.1%) < G_{12} (14.3%) < G_{16} (14.7%)]. Comparing the PF and MT results, it is possible to observe that the reductions in force production did not directly represent the increases in MT. For example, after 4 sets there was a 19.4% reduction in PF with a 12.5% increase in MT, on the other hand, after 16 sets the PF reduction was 40% with a 14.7% increase in MT. So, based on these results, it is possible to hypothesize two scenarios: 1. there is a non-linear relationship between cell swelling and neuromuscular fatigue, or 2. there may be a limit of cell swelling after a certain number of sets/repetitions associated with concentric muscle failure.

Finally, the rating of perceived exertion (sRPE) is frequently used to indirectly quantify the level of effort after sets, exercises, and RT sessions (Halperin & Emanuel, 2019; Marchetti, 2022). The sRPE represents a relationship between the physiological and performance measures and assists in quantifying the overall load (Halperin & Emanuel, 2019). In this study, it was hypothesized that all RT protocols induce similar sRPE corroborating the main hypothesis. It is well known that sRPE is affected by the level of neuromuscular fatigue after RT protocols for recreationally-trained participants, however, in this study, all RT protocols presented high sRPEs (8.3-9.4 A.U.). Probably, the lack of significant difference for the sRPE scores was that the sets in all RT protocols were performed until concentric muscle failure. Therefore, even with a small (and non-significant) trend between RT protocols (G_{16}>G_{12}>G_8>G_4), thus, it is possible that when the intensity is similar and close to muscular failure, the total number of sets does not affect the perceived exertion. Finally, the RT protocols (G_8, G_{12}, and G_{16}) showed lower ANR values when compared to G_4, however, TNR showed increases directly related to the number of sets. The TUT increased in all RT protocols, however, G_{12} had the most significant increase when compared to G_4, G_8, and G_{16}. PF was directly affected by progression in the number of sets, however, all RT protocols induced similar increases in MT. The sRPE was high and similar across all RT protocols. It is well known that certain levels of metabolic stress and mechanical tension are required to induce chronic adaptations such as hypertrophy. On this matter, Brigatto et al., (Brigatto et al., 2022) investigated the chronic effects (8 weeks) of 16, 24, and 32 weekly sets per muscle group on muscular strength and hypertrophy in trained men. Each muscle group was trained twice a week with 8, 12, and 16 sets per RT session per muscle group. The weekly total load lifted was higher for 32 weekly sets when compared with 24 (38.0%) and 16 (57.1%). Muscle thickness of the biceps brachii, triceps brachii, and vastus lateralis was evaluated after 8 weeks. The results showed that 32 weekly sets per muscle group presented higher values compared to 24 and 16 weekly sets per muscle group.

This study has some limitations that should be considered when interpreting the current results. First, we measured neuromuscular fatigue via force production, maybe measurements of lactate or by-products from the metabolism could improve the understanding of the metabolic stress induced by several sets. Second, the findings of this study cannot, necessarily, be generalized to other muscle groups, RT exercises, RT protocols, or different populations including adolescents, athletes, and the elderly.

5 Conclusion

In the present study, the highest mechanical stress was observed in the RT protocol with 16 sets since more sets and repetitions were performed with 10RM (the same external load used in all RT protocols); however, the TUT was higher in the RT protocols with 16 and 12 sets. Regarding metabolic stress, all RT protocols induced high cell swelling and reduced force production. Thus, summarizing the results, RT protocols between 12 and 16 sets may be a better option to induce high and similar levels of metabolic stress and high levels of mechanical tension.

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Conflict of Interest

The authors of this study have declared that they have no conflict of interest to report.

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Ethical Approval

Ethical approval was obtained from the Human Research Ethics Committee of the California State University-Northridge, under protocol (00001788/2018). It was written according to the standards established by the Declaration of Helsinki.

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Adult Outdoor Play Preferences: Why Nature Space Design Matters

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Abstract

Adults from many communities who value unstructured, outdoor play and want to play have limited resources to engage in play (Talarowski et al., 2019). Many parks and playgrounds today are designed with children in mind and do not offer many adult-friendly play options. The purpose of this exploratory study was to examine outdoor and indoor adult play preferences to establish a baseline for adult play or nature space design. The survey was distributed to male (N=61) and female (N=261) 18–80-year-old participants through email and posts on Facebook, Instagram, and Twitter and given a three-week window to complete. The participants were asked to pick their five top activity preferences. Overall, 33% of the participants preferred nature activities, 24% preferred playground equipment, 22% preferred sports, and 21% preferred large-yard games. The top preferences predominately came from nature activities and large-yard games. Responses from write in questions showed this group of participants preferred being outdoors (84%), active (85%), and socially driven (97%). More opportunities that match these specific preferred activities must be considered so that adults can take full advantage of the benefits play can provide.

Keywords: adults, play, outdoors, nature, recreation

Play is essential in the development of healthy children and continued health throughout their lifespan as adults (Van Fleet & Feeney, 2015; Yogman et al., 2018). Research shows the healthiest form of play for children and adults is unstructured play (Gray, 2017; Louv, 2009; Rhea, 2022; Yogman et al., 2018). Unstructured play is defined as child-directed, voluntary, intrinsically motivated, imaginative, and involves an active and relaxed frame of mind (Gray, 2017; Rhea & Richun, 2018; Yogman et al., 2018). Researchers have seen this type of play reflected most often in children and very rarely in adults (Burr et al., 2019). Research has shown play is essential for brain development (Burr et al., 2019; Medina, 2017; Piaget, 1962), fine/gross motor skills (Dankiw et al., 2020), coordination, balance, executive function (Lee et al., 2020), and social/emotional skills (Clark & Rhea, 2017; Rhea, 2022; Yogman at el., 2018). In addition, unstructured play opportunities seem to be most beneficial when combined with the outdoors and nature (Dankiw et al., 2020; Kemple et al., 2016; Louv, 2016). Engaging in unstructured, outdoor play enhances whole health development and maintenance for a lifetime (Farbo & Rhea, 2021; Farbo et al., 2020; Herrington & Brussoni, 2015). The benefits include higher levels of physical activity generated daily (Farbo & Rhea, 2022; Farbo et al., 2020); healthier body fat percentages (Farbo & Rhea, 2021; 2022); less stress and anxiety (Kirby et al., 2022); greater improvements in creativity, imagination, and problem-solving (Hunter et al., 2020; Lee et al., 2020); and improved emotional resilience, self-esteem, and self-confidence (Gibson et al., 2017; Gray, 2017; Medina, 2017).

A common misunderstanding among adults is that only children should engage in unstructured, outdoor play even then (Deterding, 2018). Present-day young and middle-aged adults, Millennials (born 1980-1995) and Gen Z's (born 1996-early 2000s), have experienced a much different childhood than adults from the Baby Boomer years (born 1946-1964). The Millennial adults (current ages 26-41) were exposed much more to organized, traditional sports as children and adolescents, whereas GenZ's (current ages 18-25) have been more exposed to and interested in adventure, alternative, or e-gaming (Auxier & Patterson, 2022). Both generations are highly competitive and think they are failures if they lose. Each generation has been exposed less and less to the outdoors and unstructured play due to the increased importance of academics, outdoor safety, and technology. Children today spend over eight hours daily on some form of technology, reinforcing staying indoors and engaging in sedentary activities (Rhea, 2022; Yogman et al., 2018). Both generations have also experienced a culture where responsibility and decision-making have shifted to the adult, while children have little choice in what they want to do.

Conversely, Baby Boomers grew up when a lot more emphasis was placed on play, and children had much more control over their lives (Gray, 2017). In school, the focus was more on whole child development and one assessment given at the end of each year, but only to determine the child's developmental level. The Millennial and Z generations have been compromised by multiple assessments yearly, and their developmental level has been replaced with an academic outcome score, which determines their worth in school (Rhea, 2022). The Baby Boomers had 60 minutes of daily recess, 50 minutes of physical education, music, or art rotation, and four hours of classroom content in a 6-hour school day (Gray, 2017). Teachers were given a great deal of freedom on the development needs of the children rather than a test score (Gray, 2017; Lazarin, 2014). At home, children were given much more freedom to roam and explore further away from home without parental supervision. If families had it, technology was a black-and-white television with four channels and one residence phone line. It was much more common to see children walk to school and play outdoors until dusk daily than stay inside and watch TV. With such a drastic change in how children were exposed to the outdoors and specifically unstructured play 40-50 years ago vs. today, it is no wonder that our focus promoting unstructured, outdoor play has been for children and not as much for adults who had already missed play as children. Since many young adults today have truly never been able to experience play at its full potential, it is important that they learn the value of play now to receive all the benefits it can provide through their aging years.

When adults are asked if they play, they either say they do not have time to play, have difficulty deciding what play is or refer to structured physical activities such as basketball or soccer or indoor gaming activities (Burr et al., 2019). Structured play is typically competitive and involves sports and games guided by rules, boundaries, keeping score, and set strategies (Burr et al., 2019; Frank et al., 2018). Participation in this type of play depends on others to be available, the adult still wants to be competitive, and the body can still do skills required for the structured activity (Capuozzo et al., 2019; Frank et al., 2018). As adults age, play becomes obsolete, with more time spent playing indoors or watching children play than playing themselves.

Today's society has become much more comfortable with indoor activities than going outdoors. Those who engage in indoor activities as their form of play often gravitate to sedentary and solitary activities as they are restricted by the available space and equipment (Lee et al., 2020). Outdoor play provides a sustainable immune system through exposure to sunlight, fresh air, and nature. The sun promotes the release of serotonin in the body, which can improve emotional states, decrease stress levels, and enhance brain function (Holick, 2016; Louv, 2016). Even with all these known benefits of unstructured outdoor play, it is very rare to see adults outside playing, which parallels the lack of children's outdoor play (Deterding, 2018).

Moreover, for adults who value unstructured, outdoor play and want to play, many communities have limited resources to engage in play (Talarowski et al., 2019). Many parks and playgrounds today are designed with children in mind and do not offer many adult-friendly play options. Gyms and recreational centers provide more structured and mainly indoor activities such as weightlifting or organized sports, which many adults, especially aging adults, do not prefer (Burr et al., 2019). Even if adults are comfortable with outdoor play, they may feel they need more options to engage in unstructured play as children do. Unfortunately, no literature suggests what kind of play activities adults would be interested in, even if play spaces were designed specifically for them. Based on this evidence, play can be a vital connection to improved adult health and longevity. However, not all forms of play are created equal, and the appropriate conditions and environment are essential for the best adult health benefits.

Therefore, the purpose of this exploratory study was to examine adult play preferences in general but also to determine any sex and age play differences. Due to the need for more evidence on adult outdoor and indoor play preferences, this study fills a gap in the literature to establish a baseline for adult play or nature space design work based on adult preferences.

1 Methods

1.1 Participants

Participants were recruited through social media, local recess groups, students, friends, family, and by electronic mail in an effort to maximize responses. Most participants were recruited from the mid and south regions of the country. Both males and females were included from three different age groups to represent the young adult (18 to 39 years old), middle adult (40 to 59 years old), and older adult populations (60 years and older). Participants had to be at least 18 years old to be included.

A three-week collection window was determined two years post-COVID. This collection period was scheduled after adults could be in public spaces again for work and other activities. At the end of three weeks, 410 responses had been collected. However, 88 responses were excluded because of missing data for a final total of 322 participants. Table 1 provides the participant distribution by sex and age. The lowest group representation was the 60+ male group with seven participants. All other group representation ranged from 13 to 124. Females (N=261) responded more to the survey than males (N=61).

Table 1: Distribution of Participants by Sex and Age Group

Sex	Age Group	N
Male	20-39	41
	40-59	13
	60+	7
	Total Males	61
Female	20-39	124
	40-59	100
	60+	37
	Total Females	261
	Total	322

1.2 Measures

An electronic survey administered through Qualtrics® was used to determine adult play preferences. No standardized assessment tool was identified in the literature to measure different activity types, so the researchers developed the survey used in this study. A pilot study was completed first to test the survey. The pilot participants (N=214) were given a random assortment of pictures associated with different types of play. These pictures included similar activities used in the current study, presented in Table 2. Participants were asked to select their top five play choices within the 27 pictures available. Since it was impossible to include every activity associated with play, participants could write-in any activity not included at the end of the survey. Based on the participant results and feedback, the researchers then revised the original survey to add clearer pictures and descriptions so that participants could better understand the activity they were selecting. The new survey also provided pictures that enlarged when selected for better viewing. The final survey also divided the play choices into four different themes with 38 different items, reflective of the feedback given from the pilot survey. The participant still had an opportunity to write-in other play activities within the themes if not seen in the choices.

The revised survey began with two prompts to better focus respondents. The first prompt asked the participants to think about activities that they would like to play or enjoy playing. The second prompt asked the participants to think about activities that would motivate them more to play if a park offered them to the public. Following the prompts, directions were provided on navigating the survey and then age and sex data were collected. The second page of the survey, Table 2, consisted of the 38 different pictures and descriptions of various play activities categorized into four themes: large-yard games, nature activities, sports, and playgrounds with equipment. Large-yard games and sports were considered structured activities since they are typically considered competitive and involve sports and games that are guided by rules, boundaries, keeping score, and set strategies (Burr et al., 2019; Frank et al., 2018) while nature activities and playgrounds with equipment were considered unstructured activities since they are typically considered more self-directed, voluntary, and imaginative activities (Gray, 2017; Rhea & Richun, 2018; Yogman et al., 2018). Participants were given the opportunity to write in preferred activities not provided in the pictures, as well as provide their most favorite and least favorite activities selected. They were then asked if their preferences in play activities had changed as they aged, to which they would respond yes or no. Finally, they were asked whether they prefer indoor or outdoor play, active or sedentary play, or if they prefer to play alone or in a group. The survey took approximately ten minutes to complete, and all responses were anonymous.

1.3 Procedures

The survey was distributed to participants through email and posts on Facebook, Instagram, and Twitter and given a three-week window to complete. Participants were encouraged to forward the survey to friends, colleagues, and family who they felt would be interested. We felt this would be the best way to collect a wide range of interests by age and sex. Researchers would send reminders through the same recruiting methods at the end of each week. At the end of the second week, limited responses for males and 60 and older populations were collected. Therefore, in the third week, researchers targeted those populations by asking for responses from the two lower number groups in the emails and social media posts.

1.4 Data Analysis

Data analysis was conducted using the IBM SPSS software Version 27. Researchers coded the data by age and sex before analyzing the data. Descriptive statistics were used to examine demographic and survey response data. Frequencies were used to determine the top ten most popular choices for play among the participants. Participants needed to complete the survey in full to be included in the final analysis.

2 Results

2.1 Play Preferences for All Participants

Figure 1 provides the ten most selected play activity preference responses. Cornhole received the most responses at 263, and cross country received the least number of responses at 49. Overall, 33% of the participants preferred nature activities, 24% preferred playground equipment, 22% preferred sports, and 21% preferred large-yard games.

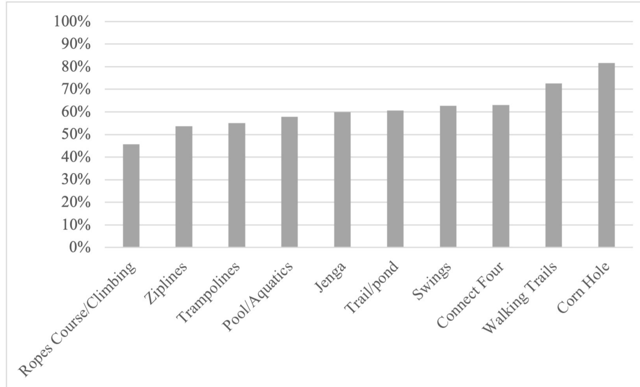

Figure 1: Play Preferences of All Participants

2.2 Play Preferences by Sex

The top ten preferred activities by sex are provided below in Figures 2 and 3. Cornhole received the most male (N=50) and female (N=213) responses. Walking trails were the next preferred activity for both sexes. Interestingly, males preferred obstacle courses (N=31) and open fields (N=32), whereas females preferred ziplines (N=138) and aquatics (N=154). The least observed male selection overall was the see-saw with 49 responses, whereas the least female observed selection overall was golf with 38 responses. Male activity preferences by theme showed 32% preferred nature activities, 28% preferred sports, 21% preferred playground equipment, and 19% preferred large-yard games. Female activity preferences by theme revealed 33% preferred nature activities, 25% preferred playground equipment, 21% preferred large-yard games, and 21% preferred sports.

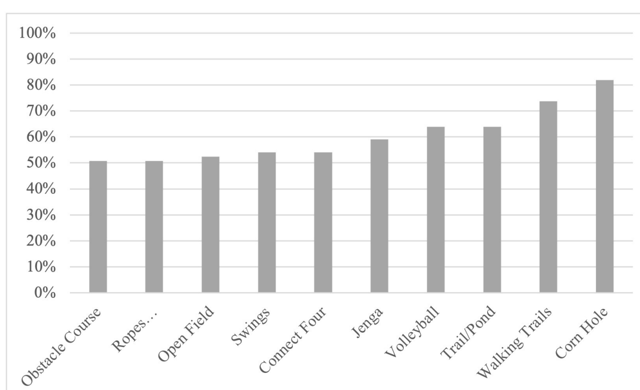

Figure 2: Play Preferences of Males

Table 2: Survey Subsections and Activity Choices

Subsection	**Choices**
Structured Play	**Large-yard Games:** Chess, Cornhole, Chinese Checkers, Checkers, Connect Four, Jenga **Sports:** Pickleball, Croquet, Tennis or Badminton, Basketball, Volleyball, Disc Golf, Bocce Ball, Golf, Horseshoes, Tetherball, Shuffleboard
Unstructured Play	**Nature Activities:** Wooded walking trail with pond, Mountain biking, Outdoor musical instruments, Sandpit, Amphitheater, Kayaking, Outdoor community garden, Cross Country Skiing, Water Skiing, Large open field, Pool/Aquatic Activities **Playground Equipment:** Swings, Obstacle Course, Zip line, See-saw, Trampolines, Monkey Bars, Climbing structure/ropes course, Merry Go Round

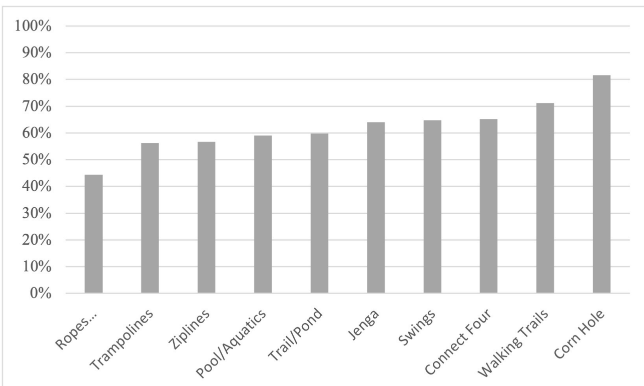

Figure 3: Play Preferences of Females

2.3 Play Preferences by Age Group

The top ten preferred activities by age group (18 to 39, 40 to 59, and 60 and older) are provided in Figures 4, 5, and 6 below. Cornhole received the most preferred responses across all age groups. The difference was in the second preferred activity across the age groups. The 18–39-year group preferred trampolines, whereas the 40 and older groups preferred walking trails. Other preferred top 10 activities did differ in order but mostly included similar activities. The least preferred activity selected for 18–39-year-olds was Chinese checkers with 13 responses. For 40 to 59-year-olds, the least preferred activity selected was pickleball with 14 responses. For 60 and older, the least preferred activity selected was the sandpit with four responses. The 18 to 39 group activity preferences by theme reflected 29% in nature activities, 28% in playground equipment, 23% in sports, and 20% in large-yard games. The 40 to 59 group activity preferences by theme reflected 34% in nature activities, 22% in sports, 22% in playground equipment, and 22% in large-yard games. Finally, the 60 and older group activity preferences by theme reflected 34% in nature activities, 27% in sports, 21% in large-yard games, and 18% in playground equipment.

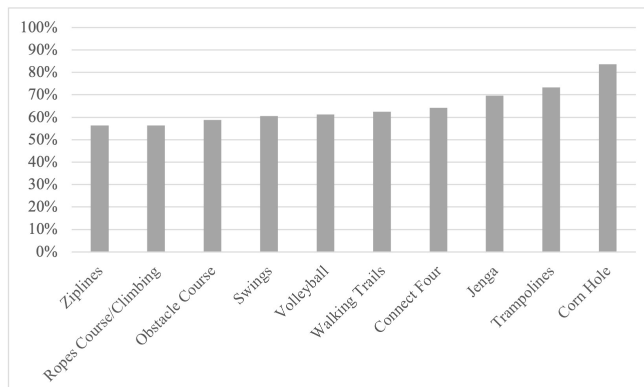

Figure 4: Play Preferences of 18- to 39-year-olds

2.4 Follow-up Question and Write in Results

Frequencies were computed on the follow-up questions: 1) Have their play preferences changed over time? 2) Do they prefer indoor or outdoor play? 3) Do they prefer perfect weather, any weather, or not to play outside at all? 4) Do they prefer active or sedentary play? 5) Do they prefer solitary play, group play, or both?

The results revealed that 235 out of 322 (73%) participants felt their play preferences had changed as they aged, while 87 (27%) said they had not. For location, 270 out of 322 (84%) participants preferred outdoor play, while 52 (16%) favored indoor play. For weather, 208 out of 322 (65%) favored play in any kind of weather, 108 (33%) favored perfect

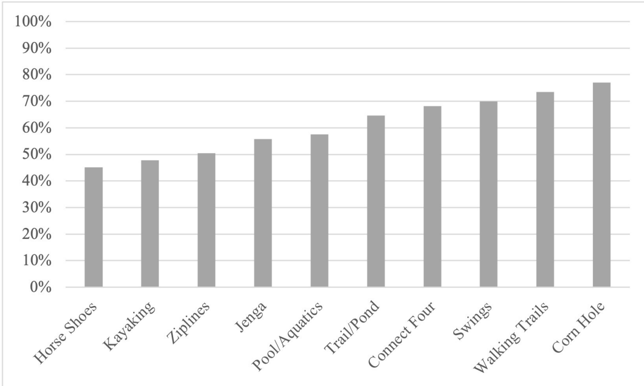

Figure 5: Play Preferences of 40- to 59-year-olds

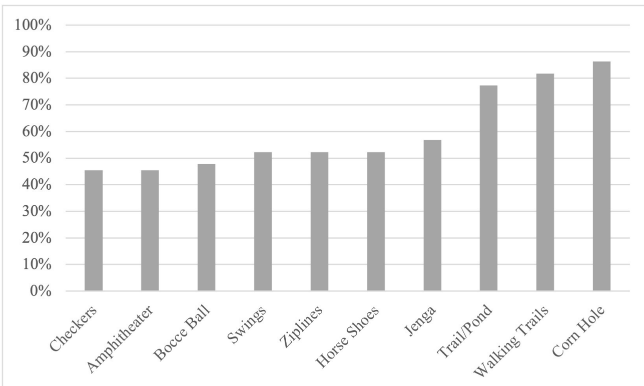

Figure 6: Play Preferences of 60 years and older

weather, and 6 (2%) preferred not to play outside at all. For the type of play, 275 out of 322 (85%) preferred active play, while 45 (15%) preferred sedentary play. Finally, 201 out of 322 (62%) stated that they preferred group play, 10 (3%) preferred to play alone, and 111 (35%) stated that they enjoyed both group and solitary play. Finally, some of the most frequent preferred activity responses written in included snowshoeing, table tennis, soccer, and yoga.

3 Discussion

Many present-day younger and mid-life adults experienced a deficiency of play opportunities growing up and consequently do not realize how important play is to living a healthier life (Walsh, 2019). As a result, it is very rare to see present-day younger adults engage in play, and many assume that it is an activity only for children (Deterding, 2018). The activities are absent for older adults because play designers do not consider adult play needs, especially for different age groups. Few resources have been considered to encourage adult play, as parks, nature spaces, and recreation centers are predominately child-centered and offer more structured activities. Therefore, the findings in this study are a first step to identify if adults want to play and, if so, what types of play adults prefer if given the space to engage in it.

Based on the researcher's determination of which activities were considered unstructured and structured, 57% of the adults preferred outdoor/nature and playground activities (unstructured activities), whereas 43% preferred sports and large-yard games (structured activities). The top five choices were unstructured activities. Sports did not appear in the top ten, which is interesting considering sports, especially pickleball, are often considered the most acceptable form of play for many adults (Walsh, 2019). Other studies corroborated these findings stating when parks offer unstructured activities such as playground equipment, splash pads, walking trails, and a lake, they prefer those activities over sport equipment (Kaczynski et al., 2014; Van Fleet & Feeney, 2015). The adults in this study may have considered sports competitive and not what they prefer when visiting parks and being in nature to play.

In the present study, large-yard games and sports were considered structured, assuming both activities would produce competition and rule-following. The survey did not allow for a clear understanding of why they chose the different activities. For example, did adults choose large-yard games for competition and following the exact rules of the game, or for cooperative play and using creativity? Many strategies can be used with large-yard games without keeping score and following the exact rules. Adults in the present study could dismiss the competition and want to challenge themselves with the strategy. It could also be older adults use the games as unstructured, and the younger adults use them as structured. Either way, large-yard games were top preferences for all ages, especially cornhole, jenga, and connect four.

Based on these limited responses, parks and recreation management might want to consider designing different types of parks: some for adults and others for child-focused landscapes. Another option to consider is different spaces within parks and nature to offer a variety of unstructured activities designated for different age groups so each group can play specific to their physical, cognitive, and social/emotional needs (Capuozzo et al., 2019; Yogman et al., 2018).

Males and females responded similarly as seven of their top ten choices were considered unstructured play elements. Again, depending on how the adults interpreted large yard games, all of the choices might have been unstructured. The only top ten sex difference was males preferred ropes/zip line activities while females preferred swings. Various activities could still be incorporated that would address male and female preferences. Across all responses, the biggest sex difference was seen in sports, as 28% of males selected these activities compared to only 21% of females. Surprisingly, both percentages were still low for adult populations. Since most male responses in the current study came from the 18 to 39 age group, this result could be due to heavy organized sport exposure during childhood that has influenced their interpretation of play as an adult (Capuozzo et al., 2019). One study showed boys preferred sports on a playground 41% of the time compared to only 11% of girls (Massey et al., 2018). Although some young adult males preferred sports over other activities, most males preferred similar activities to the females. This is a real positive since the research shows that individuals who spend more time in unstructured activities display more self-control, resiliency, and physical skills than those who spend more time in structured activities (Barker et al., 2014).

The age groups did differ on preferred activities. The 18 to 39 group seemed to pick higher intensity activities like trampolines, climbing, and obstacle courses than the middle and older age groups. On the other hand, middle-aged and older adults seemed to prefer more nature-based activities such as the amphitheater, trail/pond, and kayaking. Additionally, the 60-plus group seemed to prefer less intense activities such as bocce ball, checkers, jenga, horseshoes, and cornhole. These differences may be a result of physical disabilities that have developed, which would prevent older individuals from engaging in certain types of activities. Additionally, 86% of the older adults stated the way they play now has changed since they were children. This is consistent with the work of Burr et al. (2019), who conducted qualitative interviews with older adults about their experiences with play. The authors stated most of their participants still believe they play; however, the mode they play has changed throughout the years. They also stated they felt it was important to participate in physical and mental play to stay healthy, which could explain why checkers made it to the top ten for older adults and was not present in any other age group (Burr et al., 2019). Although not directly measured, the older adults in the current study also seemed to appreciate the value of play still and prefer various physical and mental play activities.

Lastly, most of the activities provided in the write-in responses were unstructured and included playing musical instruments, snowshoeing, and catching with a ball. Some popular structured activities offered by the participants were in the large-yard games and sports subsections, including soccer, ping-pong, and yoga. Overall, this group of participants preferred being outdoors (84%), active (85%), and socially driven (97%). These attributes increase physical activity, stress relief, and socialization, promoting healthy lifestyles (Burr et al., 2019). More opportunities that match these specific preferred activities must be considered so that adults can take full advantage of the benefits play can provide.

3.1 Limitations

This study has some limitations that should be noted. First, a potential bias could have occurred since most of the survey responses were middle-aged women. This could lead to confounding results due to similar play preferences this age group may share. Second, the survey only asked about age group and sex. Knowing their race and/or ethnicity could have been beneficial for identifying any activity differences with more diverse populations. Third, although the survey offered various activities, not all adult interests might have been captured. To compensate for that, we offered an open-ended section for the respondents to offer other activities they preferred, and we included those in the results. The researchers did not have a way to track the exact population for this study, so the generalizability of the findings is unknown. We need to improve our demographic and activity targeting strategies for future participant outreach, instead of relying solely on social media and word of mouth. As a pilot study, this was considered a beginning place to consider adult play and nature activity considerations.

3.2 Future Directions

First, a larger pool of individuals from all age groups, by sex and race needs to be collected. The recruitment strategies may have been part of the issue. Focusing on parks and sport locations for recruitment might yield a higher and more diverse response rate. Another study focused more on in-person and targeted online groups as recruitment strategies is needed to create a more robust adult population. A diverse response pool is important for identifying the most preferred activities/equipment needed in spaces for different adult age groups by sex and race. Second, a qualitative study should examine whether adults of all age groups would visit the parks and engage in the activities they selected in the survey if available. In addition, as part of the qualitative research, inquire about their past relationships with play. Asking these questions would provide a deeper understanding of adults and their real connection with play. Lastly, we would want to use the information gathered during this survey to create an actual playground to examine if adults would engage in play activities more due to the playground matching their play preferences. A future study could focus on why choices are made to clarify this distinction.

4 Conclusion

In conclusion, adults seem to prefer various unstructured activities on playgrounds and in nature rather than focusing on structured play activities such as sports. Cornhole was the number one activity and should be included in nature spaces or parks. Overall, adults do want to play, but parks and nature spaces only consider what children might like and do not focus on adult play preferences. Considering adult preferences is necessary for overall health and longevity and adds to the limited research on adult play interests.

Conflict of Interest

The authors disclosed no potential conflicts of interest regarding the research, authorship, and publication of this article.

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Examining the Relationship Between BMI, Sex, and Fundamental Movement Skill Performance in Low-Income Rural Children

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Abstract

This study examined the relationship between body mass index (BMI), Sex, and Fundamental Movement Skills (FMS) performance among low-income rural children aged 5 to 7 years. 39 children (20 boys and 19 girls) participated in the study. FMS proficiency was evaluated using the Furtado-Gallagher Child Observational Movement Pattern Assessment System (FG-COMPASS). The children's height and weight were measured to calculate BMI, which was then classified into 'normal weight' and 'overweight'. A two-way factorial ANOVA assessed the effects of sex and BMI group on manipulative fundamental motor skills (MFMS), locomotor fundamental motor skills (LFMS), and total fundamental motor skills (TFMS). We hypothesized that normal weight children would outperform their overweight counterparts in locomotor (LFMS), manipulative (MFMS), and total (TFMS) fundamental motor skills and that boys would outperform girls on MFMS and TFMS but not on LFMS. Our findings showed a significant main effect of sex on MFMS, with boys performing significantly better than girls. However, no significant main effects were found for LFMS or TFMS based on sex or BMI group. Furthermore, Pearson correlation analysis revealed weak, negative, non-significant correlations between BMI percentiles and all three motor skill scores. The study's results highlight the importance of considering sex differences when assessing FMS in children and indicate that overweight status may not necessarily relate to poorer motor skill performance in a rural, low-income context. Further research should ensure a balanced representation across BMI categories and explore the potential influence of demographic factors on motor skill development.

Keywords: body mass index, fundamental movement skills, sex differences, childhood obesity, rural children, physical activity, motor skill development

1 Introduction

Childhood obesity is a prevalent issue with long-term health implications, as children who are overweight or obese are more likely to remain so into adulthood (Nader et al., 2006). Although obesity-related health conditions such as diabetes and hypertension may not manifest during childhood, they can emerge as individuals age (Daniels, 2006). The prevalence of obesity among children aged 2–19 increased from 13.9% in 1999–2000 to 19.3% in 2015–2016 (Pan et al., 2018). Obesity arises from several factors, including genetic predisposition (Gurnani et al., 2015), low energy supply (Bandini et al., 1990), and inactivity (Rodrigues & Saraiva, 2011). In response to the growing problem of inactivity and obesity among children, professionals need to promote physical activity. A crucial component of this approach is the development of fundamental movement skills (FMS). Children proficient in FMS tend to engage in more physical activity and participate in sports more often than those with lower skill proficiency (Stodden et al., 2008; Wrotniak et al., 2006). FMS proficiency forms the basis for developing more complex motor skills in sport-like activities (Barnett et al., 2008). Therefore, examining the correlation between body weight and FMS levels in young children is critical to understanding the timing and nature of this association. Recent research indicates that obesity may influence the correlation between FMS and physical activity. Overweight children may be less proficient in FMS than their normal weight counterparts (Okely et al., 2004), suggesting a cyclical relationship between FMS, physical activity, and obesity levels (2014). Therefore, strategies to prevent unhealthy weight gain in young people should include enhancing movement abilities as an integral facet of the intervention (Okely et al., 2004). Contrary to the widespread belief that maturation is the sole factor influencing FMS development, environmental factors, practice opportunities, reassurance, and teaching contribute significantly (Clark, 2007; Gallahue & Ozmun, 1998). Similarly, sex differences in FMS performance cannot be attributed solely to physiological factors appearing after puberty (Malina et al., 2004). Recent research reveals significant disparities between boys and girls in manipulative and locomotor abilities, with boys generally performing better in manipulative skills and girls showing a trend towards better locomotor skill proficiency (Barnett et al., 2008; Zheng et al., 2022). Boys' superiority in manipulative skills may be due to their preference for sports requiring these skills (Wrotniak et al., 2006). Given this context, our study aimed to investigate the relationship between body mass index (BMI), sex, and FMS performance among low-income rural children aged 5 to 7 years. We hypothesized that normal weight children would outperform their overweight counterparts in locomotor (LFMS), manipulative (MFMS), and total (TFMS) fundamental motor skills, and that there would be a significant negative correlation between BMI percentiles and LFMS, MFMS, and TFMS. Additionally, we anticipated that boys would outperform girls on MFMS and TFMS but not on LFMS.

2 Methods

2.1 Participants

We selected our participants using convenience sampling. The study involved 20 boys (mean age in months = 78.8, *SD* = 8.17) and 19 girls (mean age in months = 79.0, *SD* = 9.76) from a K–6 public school in Shelby County, IL. The predominantly Caucasian (99%) student population came from over 50% low-income families. Children with special needs were excluded due to the requirement to perform fundamental movement skills (FMS) as part of the research protocol. Parents received a letter explaining the study's purpose and providing informed consent. Two weeks later, reminders were sent to parents who had not yet returned the signed consent forms. Only children with signed and returned consent forms were included in the study. This study was conducted following ethical standards and guidelines, and it received approval from the relevant Institutional Review Board (IRB). Participating students received a pedometer to encourage their involvement in the study.

2.2 Instrumentation and Procedures

2.2.1 Anthropometry

Eligible students underwent height and weight measurements. A calibrated electronic scale (EatSmart Products Precision Digital) measured mass to the nearest 0.1 pounds, later converted to kilograms. Students were measured without shoes and heavy clothing. The scale was recalibrated after every 15 students to ensure accuracy. The height was measured to the nearest millimeter using wall-mounted tape. We calculated the BMI for each student using the height and weight measurements.

2.2.2 Fundamental Movement Skill Proficiency

The Furtado-Gallagher Children Observational Movement Pattern Assessment System (FG-COMPASS)[1] assessed FMS proficiency during daily physical education classes. The FG-COMPASS[2] is a validated, reliable criterion-related, process-oriented assessment tool designed for school settings (Furtado & Gallagher, 2012). The assessment covered three locomotor skills (hop, horizontal jump, and skip) and five manipulative skills (throw, strike, kick, hand dribble, and catch). The gym was divided into two sections for concurrent assessment and physical education classes. Students were taken five at a time from their physical education classes and videotaped, performing the fundamental movement skills per the test protocol's instructions.

2.2.3 Scoring

We calculated BMI percentile ranks for each participant according to the CDC guidelines (CDC, 2022a). Based on these results, we classified the participants into four categories: underweight,

[1] Formerly titled Furtado-Gallagher **Computerized** Observational Movement Pattern Assessment System.

[2] https://fgcompass.com/

healthy weight, overweight, and obesity. It is important to note that none of the students were deemed underweight. As per the test protocol, children received a score from 1 to 4 based on their performance for each fundamental movement skill. Each participant received a score for the locomotor subscale, the manipulative subscale, and the total test. Before data collection, videos of children performing locomotor and manipulative skills were used to train the principal investigator (PI) in the FG-COMPASS testing protocol. The PI and an experienced FG-COMPASS practitioner classified eight videos per skill. We decided that weighted kappa values below 0.8 required additional discussion between the PI and the expert to ensure the PI was familiar with the testing protocol. This joint classification improved the internal validity of the study.

2.3 Statistical Analyses

Preliminary analyses ensured no violation of the assumptions of normality, linearity, and homogeneity of variances. Descriptive statistics were calculated for all the main variables. Factorial ANOVAs tested the main effects of sex and BMI group (normal weight versus overweight) and the interaction between these two factors on manipulative fundamental motor skills (MFMS), locomotor fundamental motor skills (LFMS), and total fundamental motor skills (TFMS). A stricter significance level of alpha = .01 was adopted to control for Type I error due to multiple comparisons. Non-parametric Mann-Whitney *U* tests compared the individual motor skills of boys and girls, while Pearson's correlation analysis examined the relationships between the BMI percentile and the three motor skills scores. Pearson's criteria interpreted the strength of the correlations. All statistical analyses were conducted using the jamovi software package (The jamovi project, 2022).

3 Results

The results are presented in line with the study hypotheses. First, we will address the relationship between Fundamental Movement Skills (FMS) and Body Mass Index (BMI), followed by analyzing sex differences in FMS performance. Table 1 provides the descriptive statistics for FMS, categorized by sex and group. Participants were initially categorized into "normal weight," "overweight," and "obese" groups based on CDC guidelines (CDC, 2022b). However, due to the small sample sizes in the "overweight" and "obese" groups, these categories were merged and labeled "overweight".

Table 1: Descriptive Statistics of Fundamental Movement Skills by Sex and BMI Group

	Sex	BMI	*N*	*M*	*SD*
LFMS	Boys	1	14	7.07	2.62
		2	6	6	1.67
	Girls	1	11	7.73	2.05
		2	8	7.25	2.38
MFMS	Boys	1	14	12.14	2.32
		2	6	12.5	2.95
	Girls	1	11	9.09	2.26
		2	8	9.13	2.36
TFMS	Boys	1	14	19.21	4.25
		2	6	18.5	4.23
	Girls	1	11	16.82	3.19
		2	8	16.38	3.81

Note. LFMS = Locomotor Fundamental Movement Skills; MFMS = Manipulative Fundamental Movement Skills; TFMS = Total Fundamental Movement Skills; BMI Group: 1 = Normal Weight, 2 = Overweight.

3.1 BMI Grouping

A two-way factorial ANOVA was conducted (see Table 2) to examine the effects of Sex and BMI group on Manipulative Fundamental Motor Skills (MFMS). There was a significant main effect of Sex on MFMS, $F(1, 35) = 15.6865$, $p < .001$, $\eta_p^2 = .309$, with boys ($M = 12.32$, $SD = 0.814$) scoring significantly higher than girls ($M = 9.11$, $SD = 0.788$) - see Figure 1.

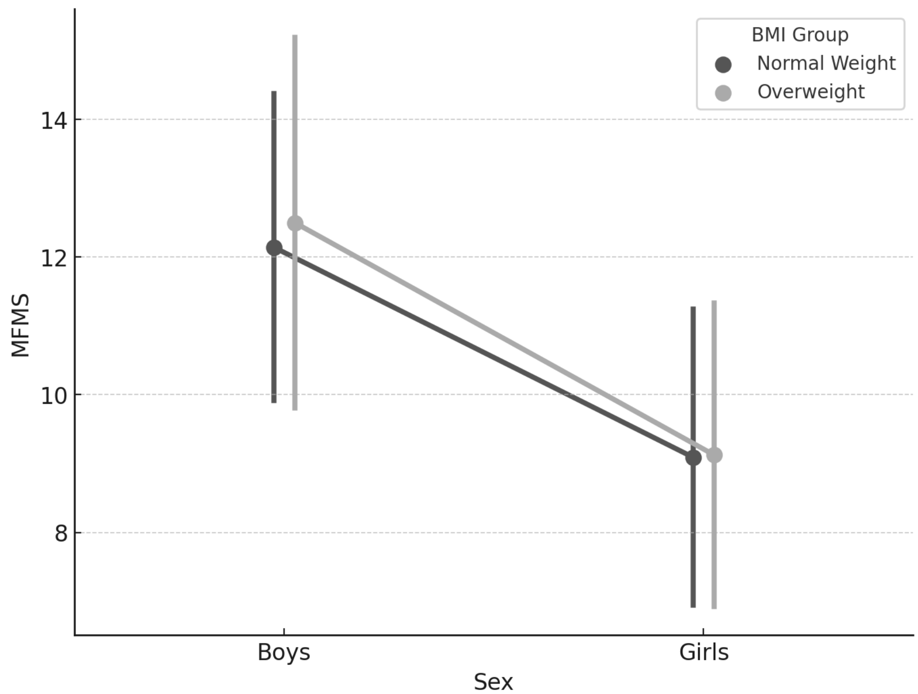
Table 2: Two-Way Factorial ANOVA Results for Manipulative Fundamental Movement Skills by Sex and BMI Group

Source	*df*	*F*	*p*	η_p^2
Sex	1	15.686	< .001	0.309
BMI	1	0.058	0.811	0.002
Sex × BMI	1	0.039	0.843	0.001
Residuals	35			

Note. η_p^2 = Partial eta squared.

However, neither the BMI group nor the interaction between sex and the BMI group had a significant effect on MFMS. Another two-way factorial ANOVA examining the effects of Sex and BMI groups on Locomotor Fundamental Motor Skills (LFMS) revealed no significant main or interaction effects. Similarly, an ANOVA evaluating the effects of Sex

Figure 1: Means Plot Comparing Boys and Girls in the Manipulative Fundamental Movement Skill Subtest.



Note: This plot illustrates the average scores obtained by boys and girls in the MFSM. The error bars represent standard deviation scores.

and BMI group on Total Fundamental Motor Skills (TFMS) found no significant main or interaction effects. In summary, while boys significantly outperformed girls in MFMS, there were no significant differences for LFMS or TFMS based on sex or BMI group.

3.2 Sex Differences for Individual Skills

Significant sex differences were found in two motor skills: striking and kicking (see Table 3. The Mann-Whitney *U* test indicated significant differences in performance between boys and girls for these skills, with effect sizes suggesting large differences. Specifically, boys outperformed girls in both striking (U = 82.0, p = 0.001, r = 0.5684) and kicking (U = 92.5, p = 0.003, r = 0.5132). In contrast, no significant sex differences were found for the other individual motor skills, including dribbling, catching, hopping, jumping, skipping, and throwing. Although the Mann-Whitney *U* test results for these skills were not statistically significant, effect sizes varied, indicating varying degrees of difference in performance between boys and girls.

Table 3: Mann-Whitney *U* test Results for Individual Motor Skills

Skill	U	*p-value*	r_{rb}
Hop	142.0	0.164	0.2526
Jump	187.5	0.954	0.0132
Skip	167.5	0.508	0.1184
Throw	129.5	0.076	0.3184
Kick	92.5	0.003	0.5132
Dribble	141.5	0.131	0.2553
Catch	165.5	0.479	0.1289
Strike	82.0	0.001	0.5684

Note. r_{rb} = Rank biserial correlation.

3.3 Correlations

A Pearson correlation analysis (see Table 4) was conducted to examine the relationships between the BMI percent and Locomotor Fundamental Movement Skills (LFMS), Manipulative Fundamental Movement Skills (MFMS), and Total Fundamental Movement Skills (TFMS). The analysis revealed weak and non-significant correlations between BMI percent and all three motor skill scores: LFMS (r = -0.261, p = 0.108), MFMS (r = -0.067, p

= 0.687), and TFMS (r = -0.199, p = 0.225).

Table 4: Pearson Correlation Coefficients Between BMI and LFMS, MFMS, and TFMS

	BMI% (r, p-value)
LFMS	-0.261, 0.108
MFMS	-0.067, 0.687
TFMS	-0.199, 0.225

Note. N = 39; r = Pearson Correlation Coefficient.

4 Discussion

This study examined the relationship between body mass index (BMI) and FMS performance among low-income rural children aged 5 to 7. Additionally, we aimed to determine if there were sex differences in FMS performance. Despite our initial hypotheses, our research found no evidence to support the assertion that BMI is related to FMS locomotor, FMS manipulative, or total FMS performance. Regarding sex differences, we observed that boys and girls differed in the performance of manipulative FMS but not in locomotor FMS or total FMS. Specifically, boys performed significantly better than girls in striking and kicking. Our findings align with other studies (Graf et al., 2004; Logan et al., 2013; Wrotniak et al., 2006), which found weak negative associations between BMI and FMS performance. However, when grouping participants based on their BMI (normal weight and overweight), we could not confirm our hypothesis that FMS performance would differ based on BMI groupings. This contrasts with other studies that found significant differences between BMI groups when measuring FMS performance. For instance, Logan et al. (2013) found that children classified as "overweight/obese" by their BMI percentiles ranked significantly lower than their peers on the MABC-2 percentiles. Similarly, using the Kiphard-Schilling's body coordination test - KTK, Lopes et al. (2012) and Graf et al. (2004) found that normal-weight children of both sexes had significantly higher FMS scores than children classified as "overweight". Several factors could account for the non-significant findings among BMI groupings in relation to FMS performance. One primary consideration is the difference in participant demographics. Unlike previous studies, which predominantly involved urban populations, our research focused on participants from rural areas. Tomaz et al. (2019) reported superior performance in striking and horizontal jumping amongst rural (low-income) children, irrespective of income status, compared to their urban counterparts. This suggests that rural environments offer more play opportunities, allowing children to become proficient in some fundamental movement skills regardless of their weight status. Moreover, the inability to find a significant main effect of BMI Group on LFMS, MFMS, and TFMS may be due to the disparity in sample sizes between groups. The 'normal weight' and 'overweight' groups were not equally represented in the sample, which may have affected the ANOVA result. When sample sizes are unequal, the statistical power to detect an effect can be reduced, especially if the smaller group exhibits greater variability in the dependent variable. This underrepresentation could increase the risk of Type I errors in the larger group and Type II errors in the smaller group. As a result, the disparity in our group samples may have obscured any potential effect of BMI group on the dependent variables. Future research would benefit from ensuring a more balanced representation across BMI categories, possibly via stratified sampling or oversampling of underrepresented groups. Our study supported the second hypothesis, consistent with previous research conducted by Barnett et al. (2008) and Wrotniak et al. (2006). We found that boys (M = 12.38) outperformed girls (M = 9.11) in manipulative but not locomotor skills. This is similar to the results of previous studies, where boys were more skilled in manipulative activities than girls. One possible explanation is that boys are more interested in activities that require manipulative skills, which could contribute to this gender difference (Wrotniak et al., 2006). Interestingly, Barnett et al. (2008) found that girls scored slightly higher than boys in locomotor activities, but the difference was not statistically significant. Boys and girls in early elementary school may be attracted to activities requiring fundamental movement skills.

4.1 Limitations

Several limitations should be considered when interpreting the findings of this study. First, our sample predominantly comprised low-income, rural children aged 5 to 7 years. Therefore, the results may not generalize to children from different socioeconomic backgrounds, urban areas, or other age groups. Second, our study relied on BMI as a proxy for children's adiposity. While BMI is a widely accepted measure, it does not directly assess body fat and its distribution, which may have different implications for motor performance. Future research could benefit from including more direct measures of adiposity, such as skinfold thickness or dual-energy X-ray absorptiometry (DXA). Third, the disparity in sample sizes across the 'normal weight' and 'overweight' groups may have influenced our ability to detect significant differences in FMS performance based on BMI groupings. Future studies should aim for a more balanced sample size across groups to increase statistical power and improve the robustness of findings. The results might have been influenced by the limited sample size, particularly concerning the comparison between BMI groups. Despite these limitations, our study provides valuable insights into the relationships between BMI, sex, and FMS performance among young children in low-income, rural settings. Our findings emphasize the need for additional study to fully comprehend these relationships and their implications for children's development and health.

5 Conclusion

This study explored the relationships between BMI, sex, and Fundamental Movement Skills (FMS) performance among low-income, rural children aged 5 to 7 years. Our findings revealed no significant effect of BMI on FMS performance, indicating that children's weight status did not significantly influence their motor skills in this sample. However, we identified a significant difference in manipulative FMS performance between boys and girls, suggesting that sex may play a role in developing certain motor skills. Our results contribute to the growing body of literature examining the complex relationships between physical characteristics and motor skill development in children. Importantly, these findings underscore the need for further research to elucidate these relationships, particularly in underrepresented populations such as low-income, rural children. Despite the lack of a significant association between BMI and FMS performance in our sample, it's important to recognize the broader health implications of obesity levels and poor fundamental motor skill development. Both factors have been independently linked to adverse health outcomes, such as cardiovascular disease and reduced physical activity levels. Therefore, comprehensive strategies that promote healthy weight and motor skill development remain crucial for supporting children's health and well-being. In conclusion, our study highlights the nuances and complexities in the relationships between BMI, sex, and FMS performance. We hope our findings stimulate further research in this area, ultimately leading to more effective interventions supporting children's physical development and overall health.

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Conflict of Interest

We acknowledge that one of the authors of our manuscript is a member of the Editorial Board of this journal. We affirm that the submission has been handled according to the journal's established peer-review policy. As stipulated, alternate Board members have administered the peer review process for our manuscript, and the involved Editorial Board member has not participated in any part of the decision-making process. This ensures that the integrity of the review and publication process is upheld.

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Daily Heart Rate Variability is Higher in Regular Exercisers Versus Matched Non-Exercisers with Similar Chronic Stressor Profiles During the COVID-19 Pandemic

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Abstract

The COVID-19 pandemic increased stress levels and created new health issues amongst individuals of all ages, genders, socioeconomic status, and occupations (da Silveira et al., 2020). The purpose of this research project was to examine differences in acute daily stress using measures of daily morning heart rate (HR), the root mean square of successive differences between normal heartbeats (RMSSD), and a proprietary index of heart rate variability (HRV) compared between matched groups of exercisers and non-exercisers with similar levels of chronic stressors. The sample consisted of 20 adult subjects (10 exercisers, 10-matched non-exercisers), including ten males and ten females with a mean body mass index (BMI) of 26.6±12.87 (females = 27.53±5.34, males = 24.77±3.55). The sample was recruited from the Pueblo, Colorado community and Colorado State University Pueblo and consisted of local community members and faculty, staff, and student body members. The participants recorded their daily morning heart rate at home using a Polar heart rate monitor and the Elite HRV phone application. Chronic stressor load was measured using the Trier Inventory of Chronic Stress (TICS) (2004) at baseline, 3 and 6 weeks. The study occurred during the COVID-19 Pandemic between September 2020 and December 2020. The regular exercise group experienced a significantly lower mean HR ($p < 0.05$), significantly higher mean RMSSD ($p < 0.05$), and mean HRV ($p < 0.05$) than the non-exercisers during the study period, with no significant differences between the groups in mean chronic stressor level as evaluated by the TICS. This research provides further evidence that exercise offers a stress-buffering effect during periods of high chronic stress, such as experienced during the COVID-19 Pandemic.

Keywords: breathing, stress, tolerance, exercise, heart rate, RMSSD

1 Introduction

The COVID-19 pandemic forced an abrupt change to many individuals' routines by increasing responsibilities such as taking precautions for COVID-19 (wearing face masks, using hand sanitizers, etc.) and following stay-at-home orders (taking care of younger family members, participating in work and school online) while also reducing the opportunities to exercise. Hagger et al. (2020) suggested that chronic stressors increased dramatically during the COVID-19 pandemic as an indirect result of such stay-at-home orders and a lack of sense of belonging to social groups, which normally occur naturally because of interactions at work, school, gyms, and while traveling (Hagger et al. 2020). This phenomenon layered one stressor upon another, taxing an individual's ability to buffer stress normally. Consequently, many people's exercise routines were not being practiced regularly as before (Fallon, 2020). Jiménez-Pavón et al. (2020) also recently observed that such a sudden quarantine radically changed the lifestyles of much of the world population and limited their exercise behaviors, such that many people were no longer achieving the recommended physical activity levels necessary to stay healthy and fight off chronic illness. Brand et al. (2020) found that those who did not exercise during the lockdown period from March to May of 2020 had a worse mood than those who exercised during the lockdown period. By contrast, several researchers have also demonstrated that regular exercise resulted in lower stress levels, an increase in positive moods, decreased chronic illness, increased overall well-being and increased immunity during this time frame (Ranasinghe et al.,2020; Jiménez-Pavón et al., 2020). Recently, the ability to measure the HRV of human subjects using Bluetooth-equipped heart rate telemetry has created a new tool for directly measuring acute stress in human subjects during free-living conditions, allowing for a serial examination of their daily acute stress level over time as well (Kim et al., 2018). In addition, Chalmers et al. (2021) found that wearing a smartwatch or a chest strap to detect heart rate and heart rate variability provided accurate results in assessing both resting and stressed states, further validating such an approach. Lastly, da Estrada et al. (2021) found that HRV is an accurate measure of stress if there is a baseline measure and added acute stressors are calculated properly. The stressor load can be evaluated using the Trier Inventory of Chronic Stress (TICS), a questionnaire validated to measure chronic stressor events using self-report. The TICS has been used for over 15 years (Schulz et al., 2011) to evaluate life experiences that may create stressors. The stressors include low-income status, unemployment, and poor housing, and subject scores are based on their subjective judgments towards specific stressors such as noise, poor career prospects, and marriage conflicts, which occur over time. In addition, with excessive demands occurring within individuals' social and occupational daily activities, an increase in chronic stressors can lead to personality trait imbalances and disturbances (Petrowski et al., 2018). The TICS measures chronic stress incorporated within specific psychosocial domains and is a reliable and valid measure of chronic stressors (Petrowski et al., 2018; Schulz et al., 2011). The potential effect of regular exercise on lowering acute stress levels associated with a high chronic stressor load and increasing overall well-being has been previously studied indirectly in cross-sectional approaches examining the associations between workplace stressors, HRV, and physical activity levels (Tonello et al., 2014), suggesting the need to examine these relationships more directly in free-living conditions. Therefore, the purpose of our study was to prospectively measure the differences in matched exercisers and non-exercisers experiencing similar high chronic life stressors during the COVID-19 Pandemic, as measured by the TICS questionnaire, in their daily acute level of stress measured physiologically by daily morning HR, RMSSD, and HRV as a more direct, quasi-experimental approach to the question.

2 Methods

2.1 Participants

A mixed gender sample of 20 (10 males and 10 females) participants, including 10 exercisers (no daily exercise) and 10 matched non-exercisers (at least 30-60 minutes of exercise 5-6 days/week), were recruited from Colorado State University, Pueblo and the general community of Pueblo, Colorado. The participants included students/faculty/staff and adult community members ages 18-65 who were not currently using medications or recreational drugs likely to influence their daily stress response. The participants were classified as exercisers or non-exercisers based on their involvement in an ongoing formal exercise group or lack thereof and matched with non-exercising controls based on age, gender, and living/working conditions as matching variables. Exercise compliance in the exercising group was evaluated using reported exercise participation.

2.2 Procedures

The study was submitted and approved by the Colorado State University, Pueblo Institutional Review Board (CSUP IRB) as a human subject research study. Participants were required to review and sign a human consent form developed in this process. Each participant was issued a Polar 8 heart rate transmitter for the duration of the study and instructed in the daily use of the free Elite HRV© phone application, which was used by the subject to collect daily heart rate (HR) and calculate various heart rate variability related measures including both RMSSD and a proprietary index of HRV created by the Elite HRV company. Participants were asked not to change their daily activities throughout the study. The exercise group was expected to record when they exercised using the Elite HRV application, which downloads the data provided to Elite HRV servers. The principal investigator obtained the data from Elite HRV and saved it as a de-identified file on their password-protected computer.

2.3 Statistical Analyses

Heart rate (HR), the Elite HRV proprietary HRV index (HRV), and the associated root mean square of successive differences between normal heartbeats calculation (RMSSD) data were recorded upon waking each morning daily across 6 weeks. The mean HR, RMSSD, and the HRV index produced by the elite HRV program daily were then averaged across all measures taken over the 6-week study period to calculate each participant's individual mean score for subsequent probability analysis. The TCIS survey was implemented three times: once at the beginning of the data collection period, once at the middle, and once at the end. An average of those three measures was calculated and used as each participant's mean chronic stressor score. The data were analyzed using SPSS V 26 by applying dependent samples t-tests between groups, with participants' mean HR, mean HRV, mean RMSSD, and mean TICS scores serving as dependent variables and using an alpha level of $p < 0.05$. Individual group scores were described by calculating the mean (M), standard deviation (SD), and standard error (SE) by group for each dependent variable. The effect size for each probability test of mean differences was calculated using Cohen's d = (M1 – M2/s2p.). The strength of the effect was determined using the following scheme: Small = 0.2 – 0.49, Medium = 0.5 to 0.79, Large > 0.8.

3 Results

Descriptive measures for the subjects by group may be found in Table 1. Mean ages were not significantly different between groups ($t(19) = 0.09$, $p > 0.05$); however, the BMI was significantly higher in the non-exercising group ($t(19) = 8.75$, $p < 0.05$) than the exercise group.

Table 1: Sample Descriptive Statistics by Group

Group	Age *M*	Age *SD*	BMI *M*	BMI *SD*
Exercise (10)	26.8	14.27	24.21	3.52
Non-Exercise (10)	26.4	12.08	28.1	4.96

Note. BMI: Body Mass Index. Values in parentheses denote sample size.

Exercisers and non-exercisers exhibited no significant differences in chronic stressor levels both within specific domains (below) and overall ($t(19) = 0.127$, $p > 0.05$), as evaluated by the TICS survey tool and further illustrated in Table 2 below.

Mean HRV was significantly higher in the exercisers than the non-exercisers with a large effect size ($t(19) = 1.807$, $p < 0.05$, ES = 0.81, Mex. = 64.02 ± 2.70, Mnonex = 55.54 ± 3.83). Mean RMSSD was significantly higher in the exercisers than the non-exercisers with a large effect size ($t(19) = 1.91$, $p < 0.05$, ES = 2.92, Mex = 31.41±1.27, Mnonex =26.92 ± 1.82). Mean HR was significantly lower in the exercisers than the non-exercisers with a large effect size ($t(19) = 1.82$, $p < 0.05$, ES = 1.21, Mex= 66.11±1.93, Mnonex =76.11 ± 3.15) evaluated by the table above.

4 Discussion

The purpose of our study was to prospectively measure the differences in matched exercisers and non-exercisers experiencing similar high chronic life stressors during the COVID-19 Pandemic, as measured by the TICS questionnaire, in their daily acute level of stress measured physiologically by daily morning HR, RMSSD, and HRV as a more direct, quasi-experimental approach to the question. The first finding in this study that both exercisers and matched non-exercisers groups experienced similar high levels of chronic stressors during the COVID-19 Pandemic is not surprising given that the groups were matched on factors likely to influence chronic stressors. This finding also supports the COVID-19 pandemic scenario as ideal for assessing the daily stress responses to such unusually high stressors as a function of each subject's choice to participate in an ongoing exercise program or not. The second finding, that the self-selected exercisers experienced lower daily stress levels than matched non-exercisers, as measured by HR, HRV, and RMSSD, strongly suggests the possibility that regular exercise favorably impacts the association between high chronic stressors and ongoing daily stress response. While no experimental evidence exists examining this potential effect directly, various researchers have attempted to look at this association less directly. Early studies examining heart rate variability and exercise suggest that chronic HRV is higher, suggesting lower acute stress levels in fitter populations (Braz et al., 2020; Hertzog et al., 2018). Michael et al. (2017) reviewed the existing literature on the acute sympathetic activation created by exer-

Table 2: TICS Domain Comparisons

Domain	Exercisers/Non-Exercisers M	SE	t(19)	p	Cohen's d
Work overload	1.82	.64	0.177	0.819	0.016
Social overload	2.04	.70	0.607	0.524	0.32
Pressure to perform	1.94	.70	0.254	0.171	0.21
Work disconnect	1.82	.63	0.138	0.856	0.10
Excessive demands at work	1.81	.63	0.207	0.795	0.02
Lack of social recognition	1.76	.73	0.125	0.869	0.01
Social tension	1.79	.71	0.031	0.964	0.02
Social isolation	1.82	.62	0.122	0.871	0.02
Chronic worrying	1.83	.63	0.102	0.881	0.02
Overall Chronic Stress Screening Scale	1.78	.72	0.127	0.856	0.08

Note. t(df).

Table 3: Results HRV Exercisers and Non-Exercisers

	Exercisers		Non-Exercisers				
Measure	M	SD	M	SD	t(19)	p	Cohen's d
HRV	64.02	2.70	55.54	3.83	1.807	0.05	2.56
RMSSD	31.41	1.27	26.92	1.82	1.91	0.05	0.95
HR	66.11	1.93	76.11	3.15	1.82	0.05	3.83

Note. t(df).

cise, as evaluated using HRV, which suggests that HRV is reduced proportionately as exercise intensity increases. This finding illustrates the possible mechanism by which exercise systematically applies a stressor to the autonomic regulation of the nervous system, resulting in reduced stressor reactivity (Boutcher, 2017). In addition, a greater training load also induces a greater sympathetic activation post-exercise, which then resolves more slowly, suggesting the possibility of a dosage-based response, a concept not addressed in this preliminary study. In addition, Schinkoeth et al. (2019) compared exercisers and non-exercisers by having the participants view pictures of others exercising and found that regular exercisers view exercise pictures with a greater HRV response (greater relative parasympathetic activation) than those who were not exercisers suggesting that perceptions around exercise are modified favorably through regular exercise participation as well. Kim et al. (2018) also found that HRV responds to changes in stress levels in various situations and that this response is impacted by an individual's psychological health, suggesting the improvements in psychological health associated with regular exercise might also be a contributing factor in our second finding, as suggested by Brand et al. (2020), who found that those who exercised regularly during the COVID-19 pandemic reported a better mood than those who do not exercise. In addition, Ranasinghe et al. (2020) found that participants who engage in regular physical activity have an increase in their immune response while lowering stress levels, similar to the potential effect of exercise suggested by our results. HRV has also been shown to have a strong positive relationship with aerobic performance. At the same time, chronically low levels of HRV are associated with poor sleep quality, further increasing the effect of chronic stressors in producing acute stress (da Silveira et al., 2020), suggesting a mechanism whereby regular exercise might improve sleep and correspondingly increase parasympathetic activation and HRV. Further illustrating another possible mechanism to explain this interaction, Rominger et al. (2019) found that individuals who exercise regularly can accomplish a more spontaneous way of thinking associated with higher levels of HRV and, in so doing, reduce the onset of stress. These findings suggest that regular exercise may act through a myriad of mechanisms to achieve a reduced stress level and improved health. This study illustrates that this association persists even during a highly stressful global pandemic such as COVID-19.

4.1 Limitations

This study uses a quasi-experimental research design, whereby the groups were formed deliberatively based on pre-existing behaviors and using a matching procedure rather than a randomization procedure. This primary limitation must be recognized in interpreting these findings as an effect of exercise participation on chronic stress reduction. While a matching procedure increases the probability that the grouping variable, exercise participation, is associated with the differences observed in daily stress response, it does not eliminate the potential for a selection bias, differentiating these groups as well. For instance, the exercising group had a significantly lower body mass index than their matched counterparts, which suggests the possibility of a greater predisposition to a lower stressor reactivity or superior nutritional habits in those who choose of their own accord to exercise regularly as possible alternative mechanisms responsible for the observed differences in stress response seen in this study. A second limitation of importance is the relatively small sample size, which might increase the probability of type II error. While the sample size was adequately powerful to produce statistically significant results in most of the variables of interest, the relatively low, yet not below the chosen alpha level, p-value of 0.083 for the work overload domain comparison in the TICS data suggests the possibility that a mechanism influencing the observed differences in daily stress response may also have been differences in work-related stress between the groups if this result is a type II error attributable to inadequate sample size. Consequently, while this study provides evidence that a positive effect of regular exercise on reduced stressor reactivity may exist, it cannot be considered definitive proof of the concept.

5 Conclusion

This study found that chronic exercisers exhibit higher daily HRV levels, suggesting lower acute stress, than matched non-exercisers with similar chronic stressor loads, providing further evidence that regular exercise may reduce stressor reactivity, particularly in periods of high stressor load. Therefore, further, more directed experimental research is justified as it could provide more substantial evidence supporting regular exercise to decrease overall daily stress.

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Conflict of Interest

We have no conflicts of interest to disclose.

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Effects of Positive and Negative Self-Talk on Balance and Postural Sway in College Students

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Abstract

Self-talk pertains to phrases individuals recite aloud or internally to increase motivation and focus and is a frequently used psychological skill that promotes enhanced sport performance. Several studies have examined how different these forms of self-talk can affect the execution of specific tasks in sport, but few have examined if self-talk can improve performance in basic activities of daily living, such as balance. The purpose of this study was to examine the effects of two different self-talk strategies on static balance and body stability during a single-leg balance task. Twenty-nine participants were divided into three groups (control group, positive self-talk group, negative self-talk group) and performed a single-leg balance task on the right and left leg while donning inertial measurement units and standing on a force platform and while reciting a positive, negative, or no self-talk strategy (i.e., control). No significant differences ($p > 0.05$) were detected in the anterior-posterior center of pressure displacement and velocity, and the anterior-posterior center of mass displacement and velocity of the right and left legs. The findings of this study do not suggest that positive or negative self-talk impacts performance during a single-leg balance task.

Keywords: self-talk, motivation, balance, fall prevention, kinematics

1 Introduction

Self-talk or inner speak addressed to the self, pertains to phrases or statements individuals recite aloud or internally to increase motivation and focus (Hardy et al., 2009). This strategy has been a frequently used psychological skill (Munroe-Chandler & Hall, 2016) and has long been used to enhance performance in sports (Hardy et al., 2009). Much of the self-talk literature stems from the sport domain, with studies reporting that 85% of adult athletes engage in self-talk during sport-related activities (Nedergaard et al., 2021). The literature has widely examined self-talk, and considerable progress has been achieved in explaining the mechanisms surrounding self-talk and its influence on performance. It is primarily based on the principle that what people say to themselves and how they say it affects performance-related outcomes (Ellis, 1976; Johnson et al., 2004). As a result, self-talk has become an integral part of psychological training (Hardy et al., 1996; Hardy et al., 2008), and there is evidence to support the effectiveness of self-talk in improving learning and task performance (Bunker et al., 1993). Self-talk can enhance attentional focus (Landin Hebert, 1999), and self-talk can effectively redirect focus and attention to relevant cues needed for task success (Nideffer Sagal, 1993). Moreover, several arguments have been made in support of self-talk and its potential to regulate effort (Williams et al., 2015), enhance self-confidence (Williams et al., 2015), and reduce performance anxiety (Hardy et al., 1996). Hardy (2006) proposed that self-talk is comprised of six dimensions: 1) function (motivational or instructional), 2) valence (positive or negative), 3) overtness (out loud or in your head), 4) self-determination level (assigned or unassigned), 5) motivation level (motivating or unmotivating), and 6) frequency (Hardy, 2006). However, sport literature has predominantly focused on the function (i.e., motivational vs. instructional) and valence (i.e., positive vs. negative) of self-talk (Hardy et al., 2001). Motivational self-talk is designed in a way that is meant to increase confidence, effort, energy expenditure, and focus by creating a positive mood (Anderson et al., 1999). A study by Hatzigeorgiadis et al., 2008) examined the effects of motivational self-talk on self-efficacy and performance in tennis players and found that the athletes who utilized their motivational phrase performed significantly better and had improved self-efficacy scale scores compared to the control group, suggesting that motivational self-talk might be best for enhancing performance during gross-motor task. Landin and Hebert (1999) examined the effects of instructional self-talk and found tennis players' use of instructional self-talk cues led to improvements in their volleying performance. Therefore, instructional self-talk might improve performance during fine motor tasks (Hatzigeorgiadis Biddle, 2008). Several studies have examined how these different forms of self-talk can affect the execution of specific tasks in sports, such as golf swings, tennis swings, free throw shooting, dart throwing, and even cycling performance. Given the abundance of self-talk literature in sports, a meta-analysis of such interventions revealed a positive moderate effect size (d= 0.48; Hatzigeorgiadis et al., 2011). It was also found that self-talk interventions were more effective for fine-motor tasks involving hand-eye coordination, accuracy, and precision (Hatzigeorgiadis Biddle, 2008). Ultimately, instructional self-talk (as opposed to motivational self-talk) was most beneficial in performing fine-motor tasks. Motivational and instructional self-talk represent umbrella categories under which other subsets or variations of these self-talk strategies exist. Regarding valence among these subsets, one such category is positive self-talk. Athletes use positive self-talk statements to boost morale and enhance confidence, anxiety control, and instruction (Zourbanos et al., 2009). Negative self-talk, on the other hand, consists of worry, disengagement, somatic fatigue, and irrelevant thoughts (Zourbanos et al., 2009). Generally, positive self-talk strategies have been implemented, and overall, the findings indicate that positive self-talk can improve sports performance (Edwards et al., 2008; Hatzigeorgiadis et al., 2008; Landin Hebert, 1999; Miles Neil, 2013; Tod et al., 2009). In recent decades, researchers have examined the effects of negative self-talk with mixed results (Hatzigeorgiadis, 2008). Studies have reported deficits in task performance associated with negative self-talk strategies, while others have reported performance benefits stemming from using this strategy. Hatzigeorgiadis and Biddle (2008) examined how negative self-talk impacted running race performance anxiety. They found that athletes who reported using negative self-talk also encountered significantly higher levels of cognitive anxiety during competition, presumably leading to unfavorable performance. However, the study also revealed that athletes who reported less use of negative self-talk identified their race anxiety as facilitative rather than debilitative (Hatzigeorgiadis Biddle, 2008). Another study by Van Raalte et al. (1995) examined the effects of negative self-talk on dart-throwing performance. Participants who reported using negative self-talk displayed a significant decrease in throwing accuracy compared to a positive self-talk and control group. Identical findings were reported by (Dagrou et al., 1992), which showed that participants who utilized negative self-talk had higher error rates in dart throwing compared to a control and positive self-talk groups. Interestingly, Van Raalte et al. (1995) also identified that the negative self-talk group had significantly better expectations for future throwing performance, suggesting that negative self-talk might possess a motivating factor to enhance performance (Van Raalte et al., 1995), and both positive and negative self-talk can improve cognitive performance through different brain alterations linked to motivation (Kim et al., 2021). Given the positive effects of self-talk on enhancing sports performance, there has been growing interest in using this skill in the exercise domain. Yet, many have focused on sport-specific skills and the techniques needed to deliver specific movements, such as throwing or soccer shooting (Anderson et al., 1999; Hamilton et al., 2007). Others have also examined how self-talk can impact metabolic expenditure and endurance during anaerobic and aerobic activity (Hamilton et al., 2007; Wallace et al., 2017). The fact remains that only four studies (Araki et al., 2006; Beneka et al., 2013; Rai et al., 2015; Saebi et al., 2016) have examined how self-talk can improve performance in basic activities of daily living, specifically control of static and dynamic balance, which are essential skills needed to perform complex tasks, such as walking and navigating the environment. Araki and colleagues (2006) examined various self-talk strategies on balance performance among healthy undergraduate students. Compared to a control group, they detected improvements in balance associated with positive and negative self-talk. However, participants using a positive strategy still performed better than those in the negative self-talk group. The study by (Beneka et al., 2013) examined the influence of motivation and instructional self-talk in individuals with knee injuries and found that those who used the self-talk strategies performed significantly better on timed balance board tests. The study by (Rai et al., 2015) examined persons with intellectual disabilities and found that motivational and instructional self-talk significantly improved performance on static and dynamic balance measures. Finally, Saebi et al. (2016) examined the effects of educational self-talk on Berg Balance Scale performance. They found that self-talk was effective in improving performance among women with multiple sclerosis. These studies further emphasize the need to examine the potential effects of self-talk strategies for balance and stability in other populations. One specific task that warrants further investigation is the single-leg balance task (Araki et al., 2006), which closely relates to the single-support phase of gait (Honda et al., 2023; Jung et al., 2014). As age-related changes become more apparent, some individuals may experience decreases in single-leg balance task duration from 22 to 14 seconds, which may translate to decreased single leg-support during walking, leading to shuffled gait and diminished gait speed (Blodgett et al., 2022; Honda et al., 2023; Murray et al., 1969; Springer et al., 2007). These characteristics are prevalent in populations displaying gait deficits, such as stroke, multiple sclerosis, Parkinson's, and older adults (Jerome et al., 2015; Torchio et al., 2022). Therefore, the purpose of this feasibility study was to examine the effects of two different self-talk strategies on static balance and body stability during a single-leg balance task among healthy adults. It was hypothesized that self-talk strategies would impact balance task performance differently. Specifically, negative self-talk would negatively impact balance, while positive self-talk would improve balance, compared to the control group.

2 Methods

2.1 Participants

An a priori sample estimate of 36 participants (12/group) with a critical alpha-level of 0.05, a large effect size (d= 0.98), and a power of 0.80 was calculated in G-Power 3.1(Faul et al., 2007) using historical data (Beneka et al., 2013). Thirty college-aged adults with no history of neurological, cognitive, musculoskeletal, cardiovascular, or known gait or balance impairments were recruited. Twenty-nine participants completed the study (Table 1). Before any study sessions, participants provided written informed consent approved by the Institutional Review Board. Following consent, participants were randomly assigned into one of three groups: a control group (CON n = 9), a positive self-talk group (PST n = 10), or a negative self-talk (NST n =10) group using a random number generator and were briefed on all procedures. This study utilized one between-group factor with three levels (CON, PST, or NST) and one within-group "time" factor with two levels (pre-test and post-test). All procedures followed the ethical standards described by the 1964 Declaration of Helsinki.

2.2 Procedures

2.2.1 Warm-up & Anthropometrics

All study visits took place in the biomechanics laboratory located on campus. Upon providing written informed consent and being assigned to groups, participants completed a five-minute treadmill warm-up (Intenza Model 550Te2, Redmond, WA) at a self-selected casual walking pace. Participants selected a walking pace that mimicked "walking through the aisles of a marketplace," and this was performed under the supervision of two research staff members. Once completed, participants completed a battery of anthropometric measurements including body height and body composition (i.e., mass (kg), fat%, and body mass index (BMI)) using a bioelectrical impedance analysis (TBF-400, Tanita, Arlington Heights, IL). These pre-test procedures took approximately 10 minutes to complete. Following the warm-up and anthropometrics, participants were briefed on the study procedures and self-talk strategies for their group assignments.

2.2.2 Self-talk Protocol

To assess the effects of self-talk valance, this protocol utilized two strategies (positive and negative self-talk) and a control group (i.e., no self-talk) while performing the single-leg balance task on the right and left leg. Participants in the control group performed all balance tasks discussed previously with no self-talk strategy. The negative self-talk group participants completed the balance tasks using the following negative statement

("I am terrible at keeping my balance"). The positive self-talk group participants completed the balance tasks using the following positive statement ("I am great at keep my balance"). Participants in the PST and NST groups were instructed to employ their respective strategies aloud during the 30-second balance trial window and in their natural tone during the 30-second balance trial window. Regarding frequency, participants were required to recite their respective strategies at least ten times within the 30-second trial. They were given time to acclimate to the study environment before commencing the self-talk protocol, which lasted one hour.

2.2.3 Assessment of Central of Pressure

The posturography test quantified the balance during two different balance tasks by measuring spontaneous body sway as the participant stood on a portable force plate (ACS-00, AMTI, Watertown, MA). All participants completed a pre-test session in which they performed the single-leg left (SLL) and single-leg right (SLR) balance tasks. The body was kept upright, with arms along the sides of the body. Participants were instructed to stand as still as possible during the test. Three 30-second trials were tested sequentially for the right and left leg. In each condition, the body sway (mm) in both anteroposterior and mediolateral direction was calculated as the maximum anteroposterior and mediolateral excursion of the center of pressure, obtained from the ground reaction force data gathered by the portable force plate. The average body sway velocity was also calculated as the total sway displacement for the time in the trial.

2.2.4 Assessment of Postural Stability

Postural stability was evaluated for all participants during the completion of the balance tasks. During all balance trials, a motion analysis system (Movella, Amsterdam, ND) recording at 60 Hz was used to record the positions of feet, ankles, knees, hips, shoulders, elbows, and wrists at known landmarks. Motion data were subsequently used to compute the body center of mass (COM) displacement-velocity trajectory using known segmental parameter information.

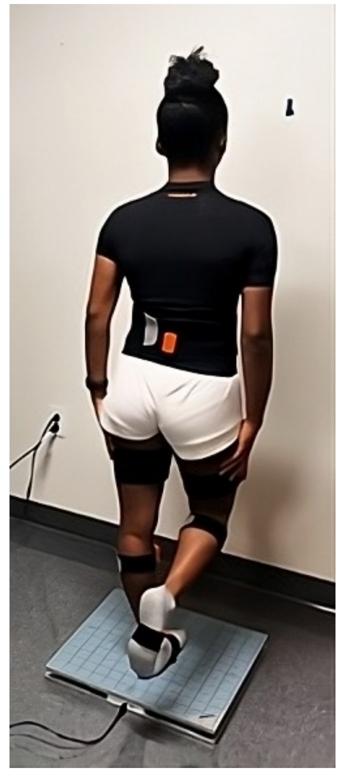

Figure 1: Experimental Set-up: Participant set-up for the single-leg balance task with participant donning inertial measurement units and demonstrating the standing task on the portable force platform.

2.3 Statistical Analyses

Data were analyzed using SPSS version 26.2. A 2 x 3 ANOVA was used to identify the potential effect of the self-talk strategies upon improving balance performance within each population (positive self-talk, negative self-talk, control). The within-subject factor is the time instants (pre-test vs. post-test) with three between-subject factors [self-talk types: (positive self-talk, negative self-talk, and control)]. For all analyses, an alpha level of $p < 0.05$ was used to determine statistical significance, and post-hoc Bonferroni corrected pair-wise comparisons were performed on significant effects if identified.

3 Results

3.1 Participants

Twenty-nine participants completed the study and reported no adverse effects. Pre-test characteristics are presented in Table 1. The Chi-Square Test showed no differences in sex between groups ($p > 0.05$), and a one-way analysis of variance (ANOVA) revealed no differences between groups in age (yrs.), height (m), or mass (kg), or body mass index (kg/m^2; $p > 0.05$).

3.2 Center of Pressure and Center of Mass Outcomes

The 2×3 ANOVA revealed no significant differences ($p > 0.05$) of the right leg at pre-test (no strategy) between groups when examining anterior-posterior center of pressure displacement $F(2, 26) = 0.26$, $p = 0.77$, $\eta_p^2 = 0.02$ and velocity $F(2, 26) = 0.29$, $p = 0.75$, $\eta_p^2 = 0.02$, and anterior-posterior center of mass displacement $F(2, 26) = 0.63$, $p = 0.54$, $\eta_p^2 = 0.05$ and velocity $F(2, 26) = 1.87$, $p = 0.17$, $\eta_p^2 = 0.13$. Additionally, no significant findings were observed for the left leg at pre-test for the variables mentioned above $F(2, 26) = 0.15$, $p = 0.85$, $\eta_p^2 = 0.01$, $F(2, 26) = 0.64$, $p = 0.53$, $\eta_p^2 = 0.04$, $F(2, 26) = 0.52$, $p = 0.59$, $\eta_p^2 = 0.03$, and $F(2, 26) = 0.90$, $p = 0.41$, $\eta_p^2 = 0.06$, respectively. When utilizing their respective self-talk strategies, no significant differences ($p > 0.05$) were detected for the right leg in the anterior-posterior center of pressure displacement $F(2, 26) = 1.35$, $p = 0.27$, $\eta_p^2 = 0.09$ and velocity $F(2, 26) = 1.73$, $p = 0.19$, $\eta_p^2 = 0.11$, and anterior-posterior center of mass displacement $F(2, 26) = 0.004$, $p = 0.99$, $\eta_p^2 = 0.01$ and velocity $F(2, 26) = 0.33$, $p = 0.72$, $\eta_p^2 = 0.02$. Additionally, no significant findings were observed for the left leg when utilizing their respective self-talk strategies for the variables described above, $F(2, 26) = 0.91$, $p = 0.42$, $\eta_p^2 = 0.06$, $F(2, 26) = 0.31$, $p = 0.73$, $\eta_p^2 = 0.02$, $F(2, 26) = 0.04$, $p = 0.95$, $\eta_p^2 = 0.003$, and $F(2, 26) = 0.56$, $p = 0.57$, $\eta_p^2 = 0.04$. The analyses also revealed no significant ($p > 0.05$) within-group differences among these variables when comparing left and right stances during the pre-test or while utilizing the respective strategies. Mean and standard error values are displayed in Figure 2-4.

4 Discussion

The purpose of this study was to examine the effects of two different self-talk strategies on balance during single-leg balance task performance. The results showed no performance effects associated with negative or positive self-talk; no benefits or decrements were observed between or within groups. These results did not support the hypothesis that negative self-talk would negatively impact balance, while positive self-talk would improve balance, compared to the control group. These findings are not aligned with most previous reports, which showed self-talk valence (positive or negative) can have a directional impact on motor task performance. An early study by (Dagrou et al., 1992) examined the effects of positive and negative self-talk on dart-throwing accuracy and found a clear distinction in performance when comparing negative and positive self-talk groups. The authors determined that throwing accuracy increased in the positive self-talk group, whereas accuracy decreased in the negative self-talk group. Although a gross motor task was used (Dagrou et al., 1992) like the present study, the self-talk strategies in each study were delivered differently. The participants recited their respective self-talk strategies in between rounds of throwing (Dagrou et al., 1992), whereas the participants in the current study verbalized their self-talk strategies during the actual motor task (e.g., balance). These differences might provide insight into the results achieved, but this requires further investigation. A later study by (Araki et al., 2006) examined the effects of various self-talk strategies on balance performance while standing on a stabilometer. It detected that participants using a self-talk strategy improved overall balance compared to a control group. However, a positive self-talk strategy produced longer periods of stability while standing on the stabilometer than the negative self-talk group, 9.28 seconds and 7.30 seconds, respectively. Although similar to our study, the participants in the study by Araki and colleagues (2006) adopted a bipedal stance while standing on the stabilometer. This stabilometer was elevated approximately 22 centimeters from the floor and tilted five degrees from the horizontal plane. A more recent study by (DeWolfe et al., 2021) determined that participants in a negative self-talk group performed much worse during the latter portion of a cycling task than participants in a motivation, neutral, and challenging group. Unlike our study, this study identified that when paired with a challenging self-talk statement (i.e., I can push through it), negative self-talk resulted in better cycling performance than negative self-talk alone. The authors stated that this finding might have resulted from participants in the negative (plus challenging) self-talk group internalizing portions of the negative self-talk statement and possibly perceiving the negative statement as challenging (i.e., I can push through it), which led to

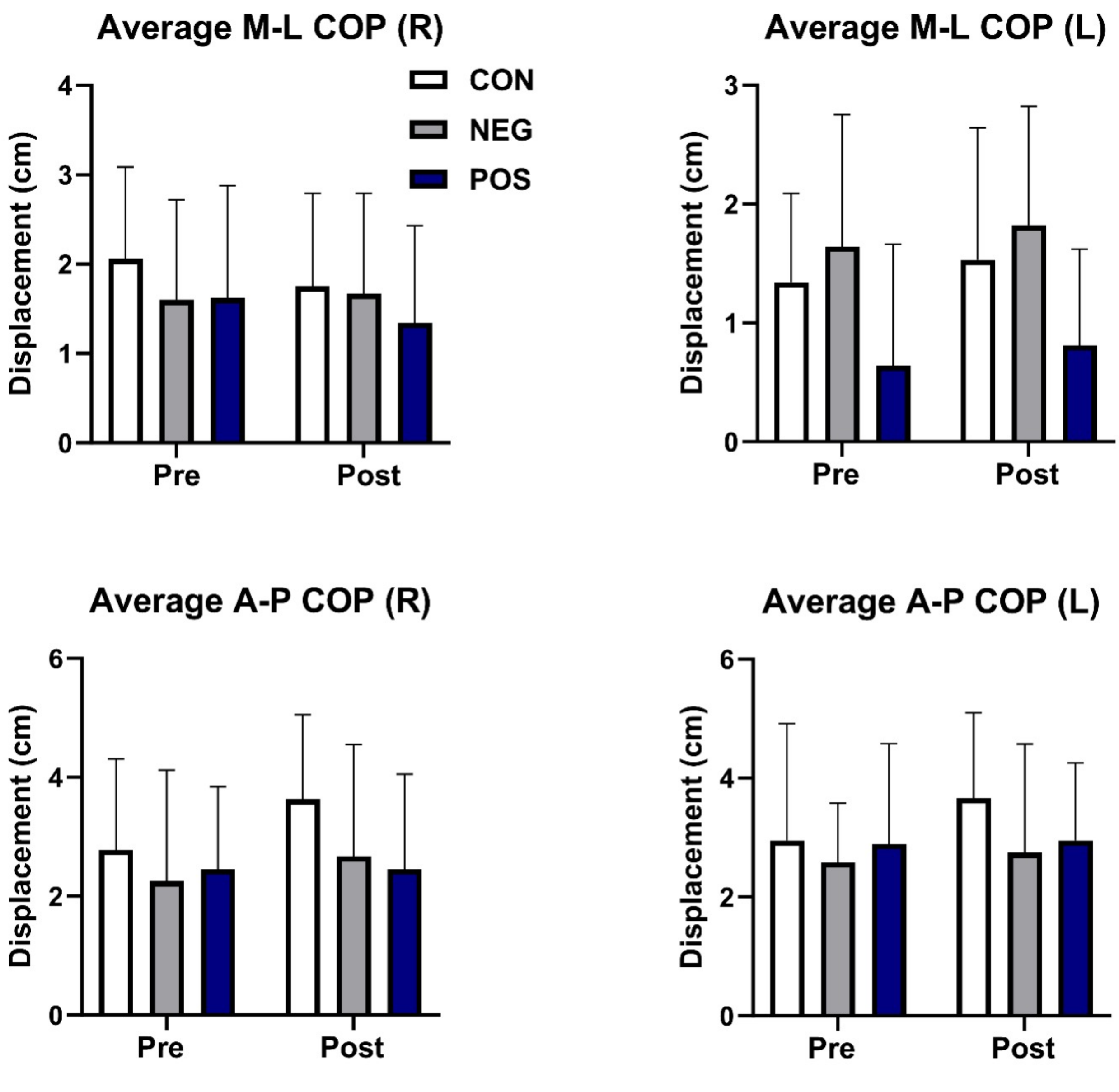

Figure 2: Participant Center of Pressure Displacement: Group means and standard error bars for the center of pressure displacement (cm) in the medial-lateral (M-L) and the anterior-posterior (A-P) direction for the right and left legs.

Table 1: Demographics for participants in the control, positive, and negative self-talk groups.

Parameter	CON (n = 9)	PST (n = 10)	NST (n = 10)	p-value
Age (years)	19.11 ± 1.05	19.70 ± 0.67	19.40 ± 1.07	0.41
Sex (female)	3	7	6	0.25
Body height (m)	1.69 ± 0.14	1.70 ± 0.11	1.69 ± 0.07	0.97
Body mass (kg)	86.03 ± 29.35	69.34 ± 20.58	77.91 ± 13.15	0.26
BMI (kg/m^2)	30.20 ± 10.72	23.67 ± 4.30	27.50 ± 5.06	0.15

Note. Values are n, mean ± standard deviation, or as otherwise indicated. One-way ANOVA and Pearson chi-squared test.

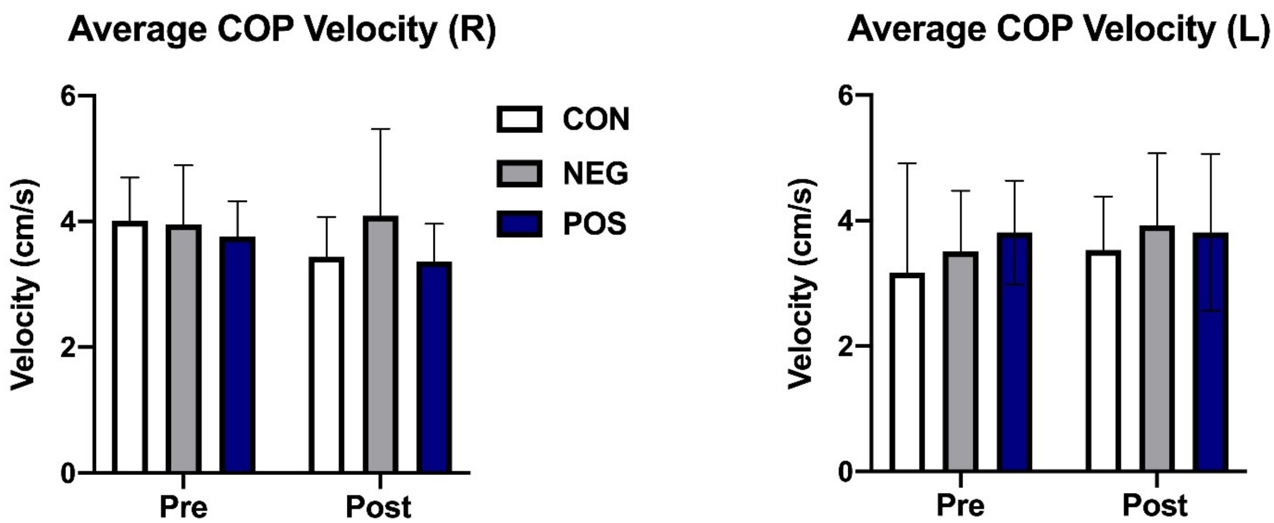

Figure 3: Participant Center of Pressure Velocity: Group means and standard error bars for the center of pressure velocity for the right and left legs.

improved performance. Additionally, participants could perceive a motivational component of negative self-talk, which could enhance performance (Hardy et al., 2009), and negative self-talk could promote a challenge state, which has been associated with improved motor task performance (Hase et al., 2019). Regarding self-talk type (i.e., motivational vs. instructional), Hatzigeorgiadis and colleagues (2014) proposed a matching hypothesis. When the task context involves fine motor skills, performers should use instructional self-talk, whereas if gross motor skills are being assessed, motivational self-talk can be more effective (Hatzigeorgiadis et al., 2014). Some evidence has been provided to support this matching hypothesis (Bellomo et al., 2020; Chang et al., 2014; Hardy et al., 2015; Hatzigeorgiadis et al., 2011). For example, throwing accuracy was better when participants used instructional self-talk, whereas the throwing distance was greater with motivational self-talk (Chang et al., 2014; Hatzigeorgiadis et al., 2004). Additionally, motivational self-talk enhanced push-up performance (Kolovelonis et al., 2011), an endurance task (Theodorakis et al., 2000), and power output in kinetic outcomes of the vertical jump (Edwards et al., 2008) to a greater extent than did instructional self-talk. The effects of motivational and instructional self-talk on dynamic balance in people with knee injuries were examined. Both strategies were effective in improving performance in the gross-motor task (e.g., dynamic balance), with no significant between-group differences (Beneka et al., 2013). It is important to note that although some of the research above

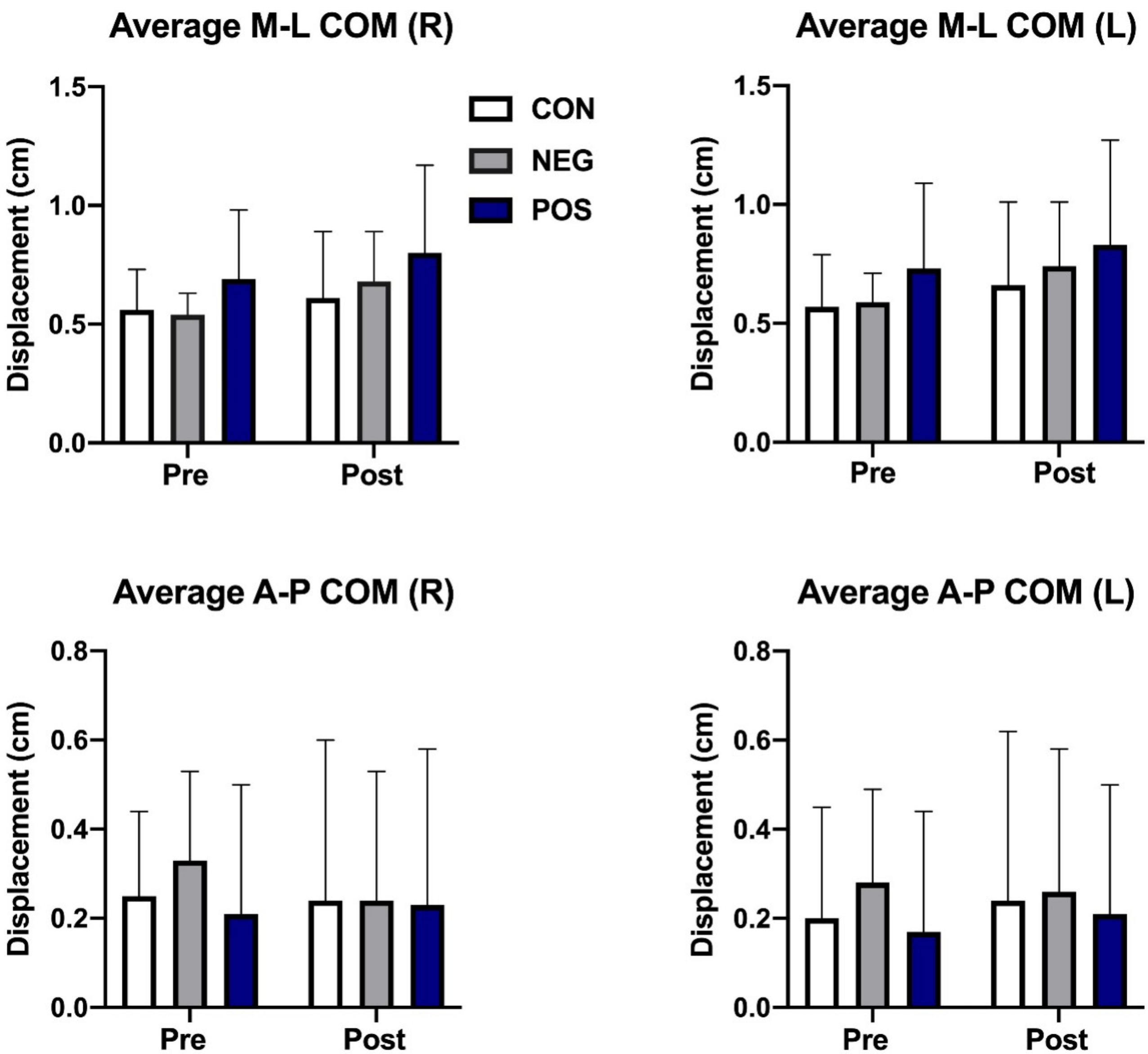

Figure 4: Participant Center of Mass Displacement: Group means and standard error bars for the center of mass displacement (cm) in the medial-lateral (M-L) and the anterior-posterior (A-P) direction for the right and left legs.

supports the matching hypothesis, the findings are not unequivocal. The findings described previously suggest that strategy-type selection is essential and primarily depends on the task demands and desired outcome. Single-leg balance performance was the desired outcome of the present study. It was interesting as this represents a vital phase in the gait cycle (i.e., single-support) where individuals are at high risk for stability loss (Honda et al., 2023; Riva et al., 2013). Several studies have indicated that the single-support phase of the gait cycle, particularly among older adults in the seventh and eighth decade, requires more intervention. As mentioned, this is mainly due to significant decreases in single-support phase duration, leading to gait modifications that can increase the risk for balance loss (Honda et al., 2023; Murray et al., 1969). Although only college-aged participants were involved in the present study, the experimental design must assess the efficacy and feasibility of utilizing positive and negative self-talk to enhance balance performance in at-risk populations. For example, approximately 80% of older participants show a deficit in balance control during the single-support phase of locomotion, especially in the seventh and eighth decade (Honda et al., 2023; Murray et al., 1969). The limited studies have looked specifically at the single-leg balance task while testing self-talk strategies (Beneka et al., 2013), and only one other has examined the effects of self-talk on balance performance in healthy college-aged adults (Araki et al., 2006), which also focused on bipedal stance. In all, four studies have examined the effects of self-talk on balance in some regards and have focused on very specific populations, including healthy college students (Araki et al., 2006), knee-injured individuals (Beneka et al., 2013), individuals with intellectual disabilities (Rai et al., 2015), and finally, women with multiple sclerosis (Saebi et al., 2016). Apart from these four studies, the effects of self-talk have almost exclusively looked at performance outcomes in sports or physical activity (i.e., running or jumping). Our study is the first to examine the impact of positive and negative self-talk strategies on a single-leg balance task. Additionally, since the effect of self-talk on biomechanical analysis has been lacking (Iwatsuki Van Raalte, 2022), this work will add a body of literature through biomechanical analysis on the effect of self-talk. Some limitations in this study might have impacted our overall findings. The self-talk strategies had a minimal self-determination component and were brief, possibly hindering any changes in performance between the groups (Hardy, 2006; Hase et al., 2019). Furthermore, the self-talk strategies were not modified throughout the visit. They lacked systematic control, meaning that if participants felt a performance improvement or decrement, they would still be required to repeat the same phrase without adaptations. Future studies will aim to improve the phrasing of the positive and negative self-talk statements to align more with each participant's personal preferences, performance needs, and changes (Hardy, 2006). Finally, although no significant differences were detected between groups in this study, whether changes were associated with the self-talk strategies or simply a practice effect remains to be investigated. The participants were given time to acclimate to the testing environment and then completed several repetitions of the single-leg task on the right and left legs as part of the protocol. In conclusion, the findings of this study do not suggest that positive or negative self-talk impacts performance during a single-leg balance task. Given the existing body of literature opposing these results, future studies must assess whether positive or negative self-talk strategies can be used as tools to potentially enhance single-leg stance balance. Future studies will aim to refine current methods, as the single-leg balance is a vital activity of everyday living that needs further investigation. This is particularly true for future applications of the self-talk strategy among older adults and other populations with gait deficits.

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Conflict of Interest

We have no conflicts of interest to disclose.

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Explicit Weight Bias Concerns in the Fitness Industry: A Quantitative Analysis

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Abstract

Limited and conflicting research is available regarding weight biases in the fitness industry, yet implications of such biases are pervasive. Individuals in larger bodies often experience stigma and prejudices due to their weight, and anti-fat attitudes have been normalized in the fitness industry and associated educational pipelines. Current literature on weight biases in the fitness industry lacks context and fails to examine these biases from an intersectional lens. Therefore, this study explored how social identities (e.g., age, gender, race, etc.) influence weight biases in fitness professionals. Fitness professionals completed an electronic survey that included demographic questions and measures of weight bias (Anti-Fat Attitudes Test; AFAT) and body dissatisfaction (Contour Drawing Rating Scale). Women in the healthy (2.02 ± 0.51) and overweight (1.97 ± 0.49) BMI categories had significantly greater total AFAT scores ($p = .003$ and $p = .023$, respectively) compared to women in the obese BMI category (1.63 ± 0.48). For participants who had completed some college, those who were classified in the healthy BMI category had significantly greater total AFAT scores (2.05 ± 0.50) compared to those in the overweight BMI category (1.72 ± 0.46). For participants who completed a master's degree, those in the healthy BMI category (2.08 ± 0.56) and overweight BMI category (2.05 ± 0.43) had significantly greater total AFAT scores compared to those in the obese BMI category (1.48 ± 0.46). There was a direct effect of gender, body dissatisfaction, race, and BMI on AFAT subscales. There was also a significant direct effect of body dissatisfaction on AFAT subscales. Across all variables, AFAT scores were highest for the physical subscale (2.69 ± 0.91) and lowest for the social subscale (1.43 ± 0.45). Fitness professionals exhibit explicit weight biases, and future research should examine the implications of such biases.

Keywords: Anti-fat bias, fitness professionals, social identities, explicit bias, weight stigma

1 Introduction

Weight bias (i.e., anti-fat bias) is unreasonable judgments about someone based on weight (Washington, 2011). It is pervasive in the health industry, including those who work as physicians (Schwartz et al., 2003), physical educators (Fontana et al., 2017), fitness professionals (Dimmock et al., 2009; Fontana et al., 2018; Robertson & Vohora, 2008), and exercise science students (Chambliss et al., 2004; Fontana et al., 2013; Langdon et al., 2016; Rukavina et al., 2010; Wijayatunga et al., 2019). In the fitness industry, potential implications of these biases include negative perceptions of larger bodied individuals' abilities, motivation, and potential job qualifications (Sartore & Cunningham, 2007). Weight stigma is defined as discriminatory acts towards individuals in larger bodies due to their size (Washington, 2011). Consequences of experiencing weight stigma include a) poor physical health, such as an increased likelihood of maintained obesity or weight gain (Sutin & Terracciano, 2013), and b) increased psychological distress, including greater rates of body dissatisfaction and symptoms of eating disorders (Vartanian & Novak, 2011). Paradoxically, individuals who experience weight stigma are more likely to avoid exercise as a result of internalized anti-fat attitudes (Vartanian & Novak,

2011) and experience an increased allostatic load (cumulative response to ongoing stress) (Guidi et al., 2021), which has a greater impact on their health than being in a larger body does (Gordon, 2020; Milburn et al., 2019). A systematic review on weight bias among exercise and nutrition professionals included 31 studies; however, only three focused specifically on fitness professionals (e.g., personal trainers or group fitness instructors) compared to "exercise professional trainees" (e.g., exercise science students). Robertson and Vohora (2008) were the first to report strong anti-fat implicit and explicit biases in fitness professionals (n = 57, "gym instructors" and "aerobics instructors"), with the bias being greater in those who had never been overweight and believed obesity was controllable. In a study surveying fitness center employees (management and administrative staff n = 15, personal trainers n = 16, fitness instructors n =19, and exercise/sport physiologists n = 20), Dimmock et al. (2009) reported a moderately strong implicit bias, but no explicit bias, towards individuals in larger body sizes. More recently, Fontana et al. (2018) found that personal trainers (n = 52) report strong implicit biases against individuals who are obese. Recently, Zaroubi et al. (2021) published a review article on the predictors of weight bias in fitness professionals and exercise science students (Zaroubi et al., 2021). Most of the studies in this review sampled undergraduate students in the exercise science field, with only four of the 18 sample fitness professionals. Of those four studies, only three included weight bias as a dependent variable (Dimmock et al., 2009; Fontana et al., 2018; Robertson & Vohora, 2008). A thematic analysis was conducted, and six themes emerged. First, exercise science students and fitness professionals strongly believe that weight is controllable and associate individuals with larger bodies with negative attributes such as laziness. Second, the relationship between gender and weight bias is still unknown as data is conflicting. Third, being enrolled in an exercise science or similar educational program is likely a predictor of weight bias. Fourth, personal and psychosocial factors (e.g., the tendency to internalize an athletic body as the ideal body shape) likely influence weight bias. Fifth, knowledge of the uncontrollable aspects of obesity (e.g., genetics) is likely to lower weight bias. Lastly, there is conflicting evidence regarding the influence of one's personal history with someone in a larger body. Chambliss et al. (2004) report that a lack of family history of having a larger body leads to higher explicit weight bias in fitness professionals and regular exercisers (Chambliss et al., 2004). In contrast, DeBarr and Pettit reported no statistical differences in weight bias held by health educators classified as overweight compared to normal weight. Little research has examined explicit weight biases of fitness professionals, and no research has focused on whether their social identities and/or role in the industry (e.g., group fitness instructor versus personal trainer) influence their weight bias. This research is particularly important due to the influential nature of this field. Clients often look to fitness professionals for advice and education on changing their health behaviors. If fitness professionals hold strong weight biases, they may contribute to a harmful cycle whereby their clients become less likely to participate and/or adhere to their health behavior changes. Fitness professionals need to have more knowledge of weight biases. Thus, the study aimed to examine the influence of age, gender, body dissatisfaction, race, role in industry, BMI, income, and education on weight bias in fitness professionals.

2 Methods

2.1 Participants

The original dataset included participants (n = 366) who identified as fitness professionals in various settings. Participants reported their role in the industry with the option to choose from certified personal trainer (n = 30), group fitness instructor (n = 107), facility club manager/director/owner (n = 2), physical/occupational therapist (n = 2), health/wellness coach (n = 2), strength and conditioning coach (n = 4), other with the option to enter their role (n = 15), and multiple (those who hold more than one role in the industry; n = 189). Due to low sample sizes within some of the roles (facility club manager, physical/occupational therapy, health/wellness coach, strength and conditioning coach, and others), only data from individuals who marked that they were personal trainers, group fitness instructors, or those who held multiple roles were included in the analysis (n = 326). The participants included a diverse sample, with 40.5% identifying as non-white (11% Black, 6.1% Asian, 8.6% Hispanic, 3.1% other, and 9.5% multi-race) and 59.5% identifying as White. Participants identified as female (n = 262) and male (n = 55), and their age was relatively equally distributed across all age groups ranging from 18-55+ (21.2% 18-24 years old, 26.1% 25-34 years old, 22.4% 35-44 years old, 17.2% 45-54 years old, and 12.9% 55 years old and older). Participants were well-educated (66% having a minimum bachelor's degree), and 43.7% reported an annual household income of $100,000 or more. Recruitment occurred via word of mouth, email, and social media. Participants were asked to complete an electronic survey about weight biases in the fitness industry. IRB approval and written participant consent were received before data collection. After four months of data collection, the authors recognized that the majority of respondents up until that point were white (84%) and subsequently amended the IRB application to include an incentive ($20 gift card) for individuals of color to participate in the study. After adjusting the recruitment language to include information about the incentive, an additional 109 fitness professionals who identified as persons of color completed the survey.

2.2 Instruments

In addition to demographic data (participants' age, weight, height, BMI, gender, race, education, income, and role in the industry), the following instruments were used in this study.

2.2.1 Anti-fat Attitudes Test (AFAT)

The modified 34-item AFAT scale (Lewis et al., 1997) measured explicit bias attitudes towards individuals in larger bodies (i.e., weight bias or anti-fat bias). This psychometrically sound scale (Dimmock et al., 2009; Lewis et al., 1997; Wijayatunga et al., 2019) consisted of a modified 5-point Likert scale with 1 being strongly disagree and 5 being strongly agree. To avoid social response bias, participants were reminded multiple times that their responses were anonymous. Positively worded statements were reverse coded, so higher scores represented greater anti-fat bias. The questionnaire includes three subscales: (1) social/character disparagement (e.g., "I prefer not to associate with fat people"), (2) physical/romantic unattractiveness (e.g., "Fat people are physically unattractive"), and (3) weight control/blame (e.g., "There is no excuse for being fat"), as well as a total composite score (Lewis et al., 1997). Individual questions were averaged for each subscale and the total AFAT composite score. Cronbach's alpha was .71, .78, and .71 for the social, attraction, and blame subscales, respectively, indicating adequate internal consistency.

2.2.2 Contour Drawing Rating Scale

The psychometrically sound Contour Drawing Rating Scale assessed participants' body dissatisfaction (Gardner & Brown, 2010). As introduced by Thompson and Gray (1995), the Contour Drawing Rating Scale utilizes the drawings of masculine and feminine human figures in the front view. Nine drawings illustrate each gender, with illustrations representing progressively larger body shapes on a scale of 1 to 9. First, the participants chose which body type they most identified with (e.g., "Which bodies do you mostly identify with?"), with group A being body shapes traditionally assigned to women and group B being body shapes traditionally assigned to men (Figure 1). As noted earlier, this data assessed participants' gender identity. The participants answered two more questions including: (1) "On a scale from 1-9, rate what your CURRENT body size based on the images above", and (2) "On a scale from 1-9, rate what you would IDEALLY want to look like based on the images above." Participants' body dissatisfaction was calculated by subtracting the number associated with their ideal image from the number associated with their current image. Positive scores indicated a desired ideal body smaller than their current perceived body size, and negative scores indicated an ideal body larger than their current perceived body size. Scores ranged from -2 to 4 and were categorized into four groups: (1) moderate dissatisfaction, desire to be larger (scores of -2 and -1), (2) no dissatisfaction (scores of 0, meaning their current body size was their ideal body size), (3) moderate dissatisfaction, desire to be smaller (scores of 1 and 2), and (4) high dissatisfaction, desire to be smaller (scores of 3 and 4). While body dissatisfaction as a construct represents a desire to be a different shape, creating groups distinguishing positive and negative scores allows for a more nuanced understanding of body dissatisfaction. A desire to be smaller should represent a greater internalization of weight bias than a desire to be larger, as a desire to have a smaller body size is consistent with the societal ideal that thinner is more valued.

2.3 Statistical Analyses

Two-way ANOVAs were conducted to examine the effects of every possible 2-way interaction of the eight independent variables (IVs) (age, gender, body dissatisfaction, race, BMI, role, education, and income) on AFAT total (Tables 1-6). When no interaction effects were found, one-way ANOVAs and MANOVAs were conducted to assess the direct effect of the IVs on AFAT total and AFAT subscales, respectively. Partial eta squared ($\partial\eta^2$) was used to measure the effect size of variables, with 0.1, 0.06, and 0.14 indicating a small, medium, and large effect size, respectively (Fritz et al., 2012). Outliers were assessed by inspection of a boxplot, normality was assessed using Shapiro-Wilk's normality test for each cell of the design, and Levene's test assessed homogeneity of variances. All data is presented as mean ± standard deviation. SPSS Version 27 was used to analyze the data, and significance was noted by a p-value < 0.05.

3 Results

There was a statistically significant interaction between gender and BMI on total AFAT scores, $F(2, 272) = 3.139, p = .045, \partial\eta^2 = .023$. Therefore, an analysis of simple main effects for gender and BMI was performed with statistical significance receiving a Bonferroni adjustment. Women in the healthy ($2.02 \pm .51$) and overweight ($1.97 \pm .49$) BMI categories had significantly greater total AFAT scores ($p = .003$ and $p = .023$, respectively) compared to women in the obese BMI category ($1.63 \pm .48$). There was also a statistically significant interaction between education and BMI on total AFAT scores, $F(9, 266) = 2.201, p = .022, \partial\eta^2 = .069$. An analysis of simple main effects for education and BMI was performed with statistical significance receiving a Bonferroni adjustment. For participants who had completed some college, those who were classified in the healthy BMI category had significantly greater total AFAT scores ($2.05 \pm .50$) compared to those in the overweight BMI category ($1.72 \pm .46$), $p = .045$. For participants who completed a master's degree, those in the healthy BMI category ($2.08 \pm .56$) and overweight BMI category ($2.05 \pm .43$) had significantly greater total AFAT scores ($p = .003$ and $p = .016$, respectively) compared to those in the obese BMI category ($1.48 \pm .46$). No other interaction effects were found. Therefore, one-way ANOVAs and MANOVAs were conducted to assess the direct effect of the IVs on AFAT total and AFAT subscales, respectively. The mean total AFAT scores for each IV are listed in Table 7.

3.1 Age

A one-way ANOVA was conducted to determine if total anti-fat bias differed by age group (see Table 1). Homogeneity of variances was violated, as assessed by Levene's Test of Homogeneity of Variance ($p = .001$). Therefore, Welch's F and Games-Howell post hoc tests were used to assess significance. There were no statistically significant differences in total AFAT scores between the different age groups, Welch's $F(4, 128.682) = 0.632, p = .640$. A one-way MANOVA was run to determine if anti-fat bias subscale scores differed by age group. Across all age groups, AFAT scores were highest for the physical subscale (2.69 ± 0.92) and lowest for the social subscale (1.43 ± 0.45), with the blame subscale scores in between (2.17 ± 0.74). No statistically significant differences existed between age groups for all three AFAT subscales, $F(12, 852) = 1.415, p = .153$; Pillai's Trace = .059; partial $\eta^2 = .020$.

Table 1: Summary of Two-way ANOVAs by Age

Measure	F	df	p	Partial η^2
Age X education	0.95	17	0.517	0.06
Age X income	1.27	27	0.174	0.13
Age X BMI	1.76	8	0.086	0.05
Age X body dissatisfaction	1.00	11	0.446	0.04
Age X industry role	1.28	7	0.261	0.03

Note. No interactions were significant.

3.2 Gender

A one-way ANOVA was conducted to determine if total anti-fat bias differed by gender (see Table 2). There was a statistically significant difference in total AFAT scores between genders, $F(1, 280) = 8.320, p = .004$. Participants who identified as men reported significantly greater total AFAT scores (2.19 ± 0.41) than those who identified as women (1.96 ± 0.51). A one-way MANOVA was run to determine if anti-fat bias subscales differed by gender. For both genders, AFAT scores were highest for the physical subscale (2.71 ± 0.92) and lowest for the social subscale $(1.43 \pm .46)$, with the blame subscale scores in between (2.17 ± 0.74). The differences between genders on the AFAT physical subscale $F(1, 280) = 6.940, p < .05$; partial $\eta^2 = .024$ and AFAT blame subscale $F(1, 280) = 6.909, p < .05$; partial $\eta^2 = .024$ were statistically significant. Participants who identified as men reported significantly greater AFAT physical scores $(3.02 \pm .91; p < .05)$ and AFAT blame scores $(2.42 \pm .62; p < .05)$ than participants who identified as women $(2.64 \pm .91$ and $2.12 \pm .75$, respectively).

3.3 Body Dissatisfaction

A one-way ANOVA was conducted to determine if total anti-fat bias differed by body dissatisfaction (see Table 3). There were statistically significant differences in total AFAT scores between different

Table 2: Summary of Two-way ANOVAs by Gender

Measure	F	df	p	Partial η^2
Gender X race	0.26	4	0.905	0.00
Gender X age	1.27	4	0.280	0.02
Gender X education	0.08	4	0.988	0.00
Gender X income	0.60	7	0.757	0.02
Gender X BMI	3.14	2	0.045*	0.02
Gender X body dissatisfaction	0.18	3	0.908	0.00
Gender X industry role	0.53	2	0.592	0.00

Note. * $p < .05$.

Table 3: Summary of Two-way ANOVAs by BMI, Body Dissatisfaction

Measure	F	df	p	Partial η^2
BMI X body dissatisfaction	1.38	4	0.240	0.02
BMI X industry role	0.73	4	0.576	0.01
Body dissatisfaction X industry role	1.13	6	0.347	0.03

Note. No interactions were significant.

levels of body dissatisfaction, $F(3, 276) = 4.147, p < .05$. Those participants in the moderate dissatisfaction, desire to be smaller group $(1.94 \pm .50)$ had significantly lower total AFAT scores compared to those in the no dissatisfaction group $(2.15 \pm .49), p = .017$. A one-way MANOVA was run to determine if anti-fat bias subscales differed by body dissatisfaction. AFAT scores were highest for the physical subscale (2.71 ± 0.92) and lowest for the social subscale (1.42 ± 0.44), with the blame subscale scores in between (2.17 ± 0.74). The effect of body dissatisfaction on AFAT subscales was statistically significant, $F(9, 828) = 2.010, p < .05$; Pillai's Trace = .064; partial $\eta^2 = .021$. Tukey post-hoc tests showed that participants in the moderate dissatisfaction, desire to be smaller group $(1.36 \pm .42)$ had significantly lower AFAT social scores than participants in the no dissatisfaction group $(1.57 \pm .49), p = .004$.

3.4 Race

A one-way ANOVA was conducted to determine if total anti-fat bias differed by race (see Table 4). Homogeneity of variances was violated, as assessed by Levene's Test of Homogeneity of Variance ($p = .001$). Therefore, Welch's F and Games-Howell post hoc tests were used to assess significance. Total AFAT scores were statistically significantly different by race, Welch's $F(5, 47.989) = 7.564, p < .001$. White participants reported significantly lower total AFAT scores ($1.86 \pm .51$) than Black ($2.14 \pm .40, p = .008$), Asian ($2.25 \pm .34, p = .001$), and Hispanic ($2.25 \pm .38, p < .001$) participants. A one-way MANOVA was run to determine if anti-fat bias subscales differed by race. AFAT scores were highest for the physical subscale (2.68 ± 0.92) and lowest for the social subscale (1.42 ± 0.44), with the blame subscale scores in between (2.17 ± 0.74). The effect of race on AFAT subscales was statistically significant, $F(15, 834) = 7.813, p < .001$; Pillai's Trace = .370; partial $\eta^2 = .123$. Tukey post-hoc tests demonstrated that participants who identified as White reported significantly lower AFAT physical scores ($2.26 \pm .72$) than participants who identified as Black ($3.46 \pm .69, p < .001$), Asian ($3.12 \pm .71, p < .001$), Hispanic ($3.30 \pm .87, p < .001$), other ($3.46 \pm .81, p < .001$), and multi-race ($3.04 \pm 1.02, p < .001$).

Table 4: Summary of Two-way ANOVAs by Race

Measure	F	df	p	Partial η^2
Race X age	0.63	17	0.865	0.04
Race X education	0.81	20	0.697	0.06
Race X income	0.75	31	0.828	0.09
Race X BMI	1.04	9	0.407	0.04
Race X body dissatisfaction	0.99	13	0.467	0.05
Race X industry role	0.44	10	0.924	0.02

Note. No interactions were significant.

3.5 BMI

A one-way ANOVA was conducted to determine if total anti-fat bias differed by BMI. There were statistically significant differences in total AFAT scores between different levels of BMI, $F(2, 282) = 3.278, p < .05$. Those participants in the healthy BMI category $(2.06 \pm .51)$ had significantly greater total AFAT scores compared to those in the obese BMI category $(1.79 \pm .53), p = .034$. A one-way MANOVA was run to determine if anti-fat bias subscales differed by BMI. AFAT scores were highest for the physical subscale (2.71 ± 0.91) and lowest for the social subscale (1.44 ± 0.45), with the blame subscale scores between (2.19 ± 0.74). There were significant differences in the AFAT subscale scores between BMI categories, $F(6, 560) = 2.126, p = .049$; Pillai's Trace = .044; partial $\eta^2 = .022$. Tukey post-hoc tests demonstrated that participants in the healthy BMI category reported significantly greater AFAT blame scores $(2.27 \pm .70)$ than participants in the obese BMI category $(1.76 \pm .77, p = .003)$.

3.6 Role in Industry

A one-way ANOVA was conducted to determine if total anti-fat bias differed by role in the industry. There were no statistically significant differences in total AFAT scores between roles, $F(2, 287) = 0.487, p = .615$. A one-way MANOVA was run to determine if anti-fat bias subscales differed by role in the industry. AFAT scores were highest for the physical subscale (2.69 ± 0.92) and lowest for the social subscale (1.43 ± 0.50), with the blame subscale scores between (2.17 ± 0.74). There were no significant differences in any of the AFAT subscale scores between the different industry roles, $F(6, 572) = 1.60, p = .142$; Pillai's Trace = .033; partial $\eta^2 = .017$.

3.7 Education

A one-way ANOVA was conducted to determine if total anti-fat bias differed by education level (see Table 5). There were no statistically significant differences in total AFAT scores between education levels, $F(6, 282) = 1.528, p = .169$. A one-way MANOVA was run to determine if anti-fat bias subscales differed by education level. AFAT scores were highest for the physical subscale (2.69 ± 0.92) and lowest for the social subscale (1.43 ± 0.45), with the blame subscale scores between (2.17 ± 0.74). There were no statistically significant differences in the AFAT subscale scores between different levels of education, $F(18, 846) = 0.083, p = .158$; Pillai's Trace = .083; partial $\eta^2 = .028$.

Table 5: Summary of Two-way ANOVAs by Education

Measure	F	df	p	Partial η^2
Education X income	1.33	30	0.123	0.15
Education X BMI	2.20	9	0.022*	0.07
Education X body dissatisfaction	0.77	14	0.700	0.04
Education X industry role	0.98	10	0.460	0.04

Note. * $p < .05$.

3.8 Income

A one-way ANOVA was conducted to determine if total anti-fat bias differed by income level (see Table 6). Homogeneity of variances was violated, as assessed by Levene's Test of Homogeneity of Variance ($p = .028$). Therefore, Welch's F and Games-Howell post hoc tests were used to assess significance. There were no statistically significant differences in total AFAT scores between the different income groups, Welch's $F(7, 108.923) = 1.472, p = .185$. A one-way MANOVA was run to determine if anti-fat bias subscales differed by income level. AFAT scores were highest for the physical subscale (2.70 ± 0.92) and lowest for the social subscale (1.43 ± 0.45), with the blame subscale scores between (2.17 ± 0.73). There were no statistically significant differences in the AFAT subscale scores between different levels of income, $F(21, 819) = 1.39, p = .141$; Pillai's Trace = .100; partial $\eta^2 = .033$.

Table 6: Summary of Two-way ANOVAs by Income

Measure	F	df	p	Partial η^2
Income X BMI	1.32	13	0.203	0.06
Income X body dissatisfaction	0.73	18	0.777	0.05
Income X industry role	0.90	14	0.557	0.05

Note. Interactions were significant.

4 Discussion

A key finding from this study is that a fitness professional's BMI interacts with their gender and education level in relation to total weight bias. Women in the healthy and overweight BMI category had significantly greater total weight bias compared to those in the obese BMI category. This supports previous findings that higher BMI is associated with lower anti-fat bias (Elran-Barak & Bar-Anan, 2018; Marini et al., 2013). These findings suggest that being in a smaller body increases women's likelihood of exhibiting greater anti-fat biases. Results from this study demonstrate that those with more education reported greater weight biases in smaller (i.e., healthy BMI category) and larger bodies (i.e., overweight BMI category) than those with less education who only reported greater weight biases in smaller bodies. Previous research has found that as physical education students advance in their degrees, they will likely demonstrate greater weight bias (O'Brien et al., 2007; Wijayatunga et al., 2019). Therefore, a relationship between education level and severity of weight biases may exist whereby, despite being in a larger body, students with more education may be more likely to hold negative beliefs about individuals in larger bodies due to internalizing the weight biases inherent in health education (Zaroubi et al., 2021). Results from this study and others demonstrate that men reported significantly greater anti-fat biases when controlling for BMI than women (Chambliss et al., 2004; Langdon et al., 2016). From a societal perspective, it is more acceptable for men to be in larger bodies than women (Heise et al., 2019). However, when BMI was included in this study's analysis, women with smaller bodies were the ones who held greater anti-fat biases. The drive for thinness that is perpetuated in the fitness industry may contribute to women internalizing messaging about what it means to be in a larger body, which may contribute to having a greater anti-fat bias. Both females and males in the healthy BMI category reported signif-

Table 7: Summary of Total AFAT Scores by Demographic and Professional Categories

	CPT			GFI			MR		
Measure	n	M	SD	n	M	SD	n	M	SD
Gender									
Female	17	2.08	0.46	84	1.96	0.53	132	1.95	0.51
Male	9	2.18	0.26	7	2.05	0.46	33	2.22	0.44
Race									
Black	1	2.24	-	12	2.03	0.52	21	2.20	0.32
Asian	1	2.18	-	5	2.45	0.41	13	2.17	0.30
Hispanic	6	2.15	0.37	5	2.14	0.33	16	2.32	0.41
White	12	1.92	0.47	63	1.86	0.52	91	1.84	0.51
Other	1	1.97	-	3	2.26	0.80	5	2.12	0.34
Multi-Race	5	2.12	0.47	5	2.22	0.28	19	2.10	0.71
Age									
18-24	14	2.07	0.45	31	1.86	0.42	20	2.09	0.44
25-34	5	2.27	0.37	22	1.97	0.42	50	1.98	0.51
35-44	-	-	-	17	2.22	0.64	43	1.97	0.61
45-54	5	1.91	0.38	15	2.12	0.64	28	2.05	0.49
55 and above	3	2.17	0.54	10	1.73	0.56	26	1.93	0.45
Education									
High school or equivalent	1	1.79	-	5	1.65	0.28	5	2.00	0.46
Some college, no degree	8	1.98	0.38	28	1.88	0.52	32	1.99	0.58
Associate degree	2	2.22	0.15	5	2.18	0.22	14	2.01	0.38
Bachelor's degree	0	-	-	33	1.96	0.48	61	2.04	0.52
Master's degree	0	-	-	21	2.04	0.61	51	1.98	0.52
Professional degree	1	2.24	-	3	2.75	0.70	-	-	-
Doctorate	1	2.77	-	1	2.34	-	3	1.40	0.12
Income									
Less than $20,000	4	1.93	0.45	14	1.73	0.32	8	2.10	0.52
$20,000 to $34,999	4	2.37	0.45	5	1.74	0.43	20	2.22	0.31
$35,000 to $49,999	2	2.18	0.33	3	1.97	0.16	22	1.89	0.50
$50,000 to $74,999	4	1.96	0.63	12	1.94	0.59	22	2.07	0.46
$75,000 to $99,999	4	2.16	0.37	13	2.22	0.57	25	1.97	0.57
$100,000 to $149,999	4	2.13	0.10	24	2.11	0.58	29	1.94	0.54
$150,000 to $199,999	1	1.88	-	12	1.88	0.32	18	1.89	0.48
$200,000 or more	3	1.78	0.55	11	1.94	0.72	17	2.08	0.67
BMI									
18.5-24.9 kg/m²	17	2.11	0.45	55	2.07	0.51	100	2.04	0.52
25-29.9 kg/m²	8	2.09	0.44	28	1.88	0.50	52	2.03	0.46
>30 kg/m²	2	1.93	0.27	10	1.89	0.62	13	1.69	0.49
Body Dissatisfaction									
Moderate, desire to be larger	3	2.16	0.48	2	2.13	0.27	5	2.30	0.23
No dissatisfaction	8	2.28	0.30	15	2.05	0.47	48	2.16	0.53
Moderate, desire to be smaller	14	2.08	0.39	64	1.91	0.53	90	1.95	0.49
High, desire to be smaller	1	1.29	-	9	2.16	0.51	21	1.80	0.52

Notes. M = mean, SD = standard deviation. CPT = Certified Personal Trainer, GFI = Group Fitness Instructor, MR = Multiple Roles. '-' indicates data not available or not applicable.

icantly greater total weight bias compared to those in the obese BMI category. These findings result from cultural norms where larger bodies are often viewed as less desirable than smaller bodies. This is seen in the fitness industry's lack of images of people with larger bodies and the current culture of dismissing people as less able, less self-disciplined, and lacking willpower (Foster et al., 2003; Hebl & Xu, 2001). Interestingly, fitness professionals in this study with moderate body dissatisfaction and a desire to be smaller reported significantly lower total and social weight bias than those without no dissatisfaction. Experiencing body dissatisfaction may increase empathy towards individuals in larger bodies, thereby reducing their weight bias. However, further examination is necessary to better understand this relationship. Similarly, the two levels of education associated with influencing the relationship between BMI and total AFAT scores (some college and having a Master's Degree) are separated by two additional levels of education (Associate Degree and Bachelor's Degree), which makes drawing any conclusion about the relationship between education, BMI, and anti-fat bias difficult. Thus, further research examining this relationship is warranted as well. Regardless of age, gender, body dissatisfaction, race, role in industry, income, or education, total AFAT scores and all AFAT subscale scores were below the anti-fat bias threshold 3. Dimmock et al. (2009) reported similar results with mean explicit weight bias values of 1.65, 2.66, and 2.92 for social, physical, and blame AFAT subscales. However, conflicting research demonstrates that fitness professionals possess strong implicit anti-fat biases (Dimmock et al., 2009; Fontana et al., 2018; Robertson & Vohora, 2008). The differences in findings could result from measuring implicit versus explicit weight bias, where implicit bias measures biases that emerge subconsciously without awareness, and explicit bias measures conscious biases (Gawronski & Bodenhausen, 2006). A limitation of this study was the use of explicit rather than implicit weight bias measures, which increases the likelihood of response bias. The participants who chose to complete this study have more favorable attitudes towards individuals in larger bodies, which is why they were interested in participating. Future research should examine how social identities and industry roles influence implicit weight biases in the fitness industry. Despite AFAT scores not being below the anti-fat bias threshold, participants still reported anti-fat beliefs, particularly for the physical and blame subscales. The blame AFAT score was consistently the greatest of all of the AFAT subscales for each of the IVs, and participants in the healthy BMI category had significantly greater AFAT blame scores compared to individuals in the obese category. While this is the first study to demonstrate such findings in fitness professionals, Chambliss et al. (2004) and Dimmock et al. (2009) reported similar, high blame subscale scores in exercise science students and fitness center employees, respectively. In most fitness certifications and curricula, there is a strong focus on preventing obesity, where there is often an oversimplification of obesity, which blames and stigmatizes individuals in larger bodies (Roehling et al., 2007; Tesh & Tesh, 1988). Interventions designed to reduce weight bias by including information about the complex nature of obesity (e.g., uncontrollable causes of obesity) have been shown to successfully reduce blame (Rukavina et al., 2010; Wijayatunga et al., 2019) and social weight bias (Rukavina et al., 2010) in undergraduate students. While future research examining the effect of similar interventions on weight biases in fitness professionals might be useful, Gibson (2021) argues that even fat activists who try to resolve individuals in larger bodies of responsibility associated with their size inadvertently support the notion of blame. By arguing that individuals in larger bodies who exercise and eat well are naturally larger and "innocent" of their body size (a term Gibson deems "good fatty"), fat activists highlight the notion that those in larger bodies who are not active or eating well ("bad fatty) are "guilty" and therefore to blame for their bodies. Thus, the cognitive response of blame in relation to one's body size is further exasperated. An additional novel finding in this study was the difference in anti-fat bias based on one's race. In opposition to Perez-Lopez et al. (2001), who reported greater anti-fat attitudes in White individuals, White participants in this study reported significantly lower total anti-fat bias compared to Black, Asian, and Hispanic participants. Similarly, White participants reported significantly lower AFAT physical scores compared to every other race. This finding contradicts Puhl et al. (2015), who found that in a U.S. sample, Black participants scored lower on fat phobia and fat bias measures compared to White participants. In the current study, breaking down weight bias specifically into the physical subscale provides an important context for the contradictory finding. The physical subscale represents how attractive or unattractive one finds fat people. This is particularly relevant for the sample population, where social norms within the fitness industry uniquely prime individuals to have stronger weight biases by framing weight loss goals to improve attractiveness. Societally, we are primed to view thin, white bodies as more attractive, which is rooted in a racist history (Strings, 2020). Research demonstrates that greater exposure to anti-fat culture leads to stronger anti-fat attitudes (Durso & Latner, 2008; O'Brien et al., 2007), which leads to internalizing such messages (Mensinger et al., 2016; Pearl et al., 2019) However, more recent messaging around body positivity, which aims to counter the views that only thin bodies are attractive and worthy, has been criticized as a white feminist perspective (Johansson, 2021). If bodies other than the white, thin ideal are considered to be unattractive, it is too much to challenge dominant stereotypes to accept all other deviant aspects of non-white fat bodies (e.g., race, hair, etc.); therefore, white women are the only group allowed the privilege of viewing their own larger bodies as attractive or adopt self-love (Johansson, 2021; Strings et al., 2019). This can then reinforce internalized views of unattractiveness for non-white fitness professionals, as they have not been able to receive the benefits of body positivity under white supremacy. In addition, other aspects of the fitness industry function under white privilege. White fitness professionals are more likely to have control and ownership over fitness spaces, which can make it challenging to create spaces that counter racist attitudes (Strings, 2020; Strings et al., 2019). People of color and those in larger bodies continue to be underrepresented in the fitness industry and have likely experienced many other biases themselves, which leads to a greater potential for internalizing other biases prevalent in the industry. Another area that needs continued exploration is the influence of one's role in the industry on weight biases. While this paper sought to understand this relationship, the small sample size within each role made it difficult to make comparisons, which limited the analysis to only comparing three roles. Additionally, most fitness professionals have many roles in the industry (e.g., personal trainer and group fitness instructor), which makes interpreting data difficult. It is also possible that the type of certification (rather than a role in the industry) influenced weight bias more.

Conclusion

This study reveals complex relationships in anti-fat biases among fitness professionals. The interaction between BMI, gender, and education level reveals intriguing patterns, challenging conventional assumptions about weight biases within the fitness industry. Both genders in the healthy BMI category express greater weight biases, indicating societal favoritism towards smaller bodies. Despite participants scoring below the defined anti-fat bias threshold, the persistence of anti-fat beliefs, especially in the blame subscale, calls attention to underlying biases not fully captured by explicit measures. The blame directed towards individuals in larger bodies may be perpetuated by oversimplified narratives surrounding obesity prevalent in fitness certifications and curricula. The study also breaks new ground by exploring racial disparities in anti-fat biases within the fitness industry. The unexpected finding that White participants report lower anti-fat biases challenges previous research, pointing to the unique influence of the fitness industry's culture on shaping perceptions. This underscores the importance of considering industry-specific contexts in understanding weight biases. In conclusion, this study unravels intricate dynamics of weight biases in fitness professionals, challenging assumptions and emphasizing industry-specific influences. It calls for ongoing research to comprehensively understand the multifaceted factors shaping biases in this unique professional domain. This study uses a diverse sample to advance the current literature on weight bias concerns in the fitness industry. This novel research is a necessary first step to future research (e.g., intervention studies) that explores how biases in the fitness industry influence the health behaviors of those seeking fitness guidance.

Conflict of Interest

We have no conflicts of interest to disclose.

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Keynote Presentation

Carole Casten, California State University Dominguez Hills

E.C. Davis Lecture

Guillermo Escalante, California State University San Bernardino

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Young Scholar Award: Training Current and Future Health-related Practitioners to Accurately and Appropriately Disseminate Physical Activity Guidelines

Jafra Thomas (California Polytechnic State University)

Current and future health-related practitioners have low awareness of physical activity guidelines (PAGs) for general and clinical populations. The purpose of the present study was to critically appraise the quality of one 2021 draft training video, which was designed to help current and future health-related practitioners give advice consistent with general adult PAGs. A descriptive qualitative analysis was performed on open-ended responses provided by undergraduate research assistants (or recent alumni) affiliated with the first author's lab and uninvolved in the video's creation. Participation was optional, anonymous, and through an online questionnaire open for seven days in April 2021 (14 invited, 8 participated, response rate = 57.14%). Participant feedback was compared to applicable standards of the RE-AIM framework (i.e., reach, efficacy, and adoption). Face validity and other quality measures were determined through qualitative analysis. The first author performed the descriptive analysis, and the second author, acting as a critical friend, independently verified the trustworthiness of the analysis. No issues were identified (i.e., a succinct and veracious analysis). Participants generally agreed the draft video was clear, concise, informative, and interesting. Participants did not perceive any major concerns with the video (e.g., non-offensive/biased), and their suggestions were used to finalize the training video (e.g., to add closed captioning, further explain a graph). Results confirmed the video had good face validity and could be effective within real-world educational settings for current and future health-related practitioners (e.g., low time burden, stimulating, informative). Future research should investigate learning outcomes to the video and its real-world implementation.

ABSTRACTS

Examining the Source of Stress Among Adapted Physical Education Teachers

Minhyun Kim (Sam Houston State University)

It is estimated that in the United States alone, eight percent of teachers leave the profession each year and this is the primary contributor to teacher shortages nationally. Adapted physical education (APE) teachers are specifically at higher risk of leaving the profession compared to other groups of teachers as they often face additional stressors such as marginalization, limited resources, and lack of administrative support. The purpose of this study was to examine the sources of stress and coping strategies among APE teachers. A total of 15 (10 female, 5 male) APE teachers who had six to 31 years of teaching experience participated in this study. Qualitative data were collected by conducting semi-structured interviews and collecting personal narratives. As a result of data analysis, the following four themes emerged: (a) high demanding workloads: caseload, paperwork, IEP meetings, and school events; (b) managing the needs of various characteristics of students with disabilities; (c) the shortage of paraprofessionals; and (d) a lack of understanding and recognition of APE. The findings indicated that all participants felt stressed while working as APE teachers and multiple factors influenced their stress. Therefore, APE teachers' workloads should be manageable. Providing stress management programs or mental health support can reduce and prevent stress for APE teachers. Additionally, it is important to create a supportive environment in which APE teachers feel comfortable addressing concerns and seeking assistance when needed.

How to Help Your Students Fall in Love with Running

Samantha Lewis (University of Idaho)

The purpose of this oral presentation is to examine the philosophic principles underlying the secret to falling in love with running. For some, the idea of falling in love with running is strange. How can we have a deep relationship with an activity? The conventional methods of teaching sport treat the body and activity as means to an end, or objects to manipulate, without awareness of how personhood is tethered to the body and activity. Hyper-competitive sports tend to desensitize the body by focusing on winning rather than kinesthetic enjoyment. But the latter is where we feel the rapture of being swept away in the sweet pandemonium of love. When movers become disjointed from their activity, their mental health and wellbeing are vulnerable. In the first four months of 2022, at least five NCAA student-athletes committed suicide. Cox (2015) surveyed 950 NCAA DI student-athletes and found that 33.2% experienced symptoms of depression, 25.7% did not know how to access mental health resources, and 44.5% had not received mental health education from their athletic department. Cox's results are attributed to a lack of mental health resources. As former student-athletes and current collegiate coaches, we can attest that student-athletes need more resources. However, rarely do people want to discuss that the "win-at-all-costs" culture in collegiate athletics is partially to blame. Coaches who care about their relationship with their students, athletes, and selves are seeking alternatives to an objective view. They desire a deeper connection with sport—filled with meaning, beauty, and joy. Thus, the purpose of our philosophic presentation is to identify how to become lovers by increasing kinesthetic, historical, and existential awareness of ourselves as runners.

Qualitative Exploration of Women's Leisure Career Interruption

Soyoun Lim (Mississippi State University)

As women gain increased access to leisure, they have more opportunities to develop a leisure career than ever before. However, maintaining a leisure career can be challenging when women are expected to be a main caregiver of the household. Leisure constraints have been used to explain how and why women drop out from casual and serious leisure. However, because career development requires more involvement and commitment than periodical leisure participation, an interruption in one's leisure career may be attributed to more significant challenges than mere constraints. This study aimed to explore women's leisure career interruption and investigate how they experience it, juxtaposed with women's gender roles and expectations. Using an interpretative phenomenological approach, in-depth interviews were conducted with 11 South Korean women who experienced such an interruption. Korean women were selected because South Korea has a traditionally patriarchal culture that has strong gender expectations on women as caregivers in the family. Five themes were identified from the interview data: changes due to a woman's life stage, social pressure on priorities, sociocultural gaslighting and a psychological threshold, lack of spousal support and a sense of deprivation, and adoption of a new leisure activity as a breakthrough strategy to relieve stress and depression from gender role expectations as a mother and wife. Based on the findings, the phenomenon of leisure career interruption is defined. Suggestions were made regarding overcoming leisure career interruption, including leisure education, family counseling, and the involvement of the spouse and other family members in education programs.

Daily Heart Rate Variability is Higher in Regular Exercisers Versus Matched Non-Exercisers with Similar Chronic Stressor Profiles During the COVID-19 Pandemic

Tina Twilleger & George Dallam (Colorado State University Pueblo)

The COVID-19 pandemic, affecting individuals of diverse demographics, escalated stress levels and introduced novel health challenges. This research aimed to explore variations in daily acute stress by analyzing daily morning heart rate (HR), the root mean square of successive differences between normal heartbeats (RMSSD), and a proprietary index of heart rate variability (HRV). We compared these parameters between two matched groups: regular exercisers and non-exercisers, all enduring similar levels of chronic stressors. Our study comprised 20 adult subjects, evenly split into exercisers and non-exercisers, including 10 males and 10 females, with a mean age of 26.6 ± 12.87 and mean BMI for females and males at 27.53 ± 5.34 and 24.77 ± 3.55, respectively. Participants were drawn from both the Pueblo, Colorado community and Colorado State University Pueblo, encompassing local community members, faculty, staff, and students. Daily morning HR data were collected remotely by subjects using Polar heart rate monitors and the Elite HRV phone application. Chronic stressor levels were assessed using the Trier Inventory of Chronic Stress (TICS) at baseline, 3-weeks, and 6-weeks. The study was conducted between September 2020 and December 2020, amid the COVID-19 pandemic. Results demonstrated that the regular exercise group exhibited significantly lower mean HR ($p < .05$), significantly higher mean RMSSD ($p < .05$), and mean HRV ($p < .05$) compared to the non-exercisers during the study period. Importantly, no significant distinctions surfaced between the groups regarding mean chronic stressor levels assessed via the TICS. This research reinforces the notion that exercise provides a stress-buffering effect, particularly during periods of elevated chronic stress, as exemplified during the COVID-19 pandemic.

Knowing Student Names in Physical Education Class: Does it Make a Difference to the Student?

David Barney, Teresa Leavitt, & Keven Prusak (Brigham Young University)

We have each been given a name that we are known by throughout our lives, including in the K-12 educational setting. Friends and teachers will address us by this name. The physical education setting offers many opportunities for the student to be addressed by their name. The purpose of this study was to examine the findings of PE teachers using student names and how it affects the students in PE class. For this study, 278 junior high school students (165 males & 113 females) participated. A survey was created based on literature dealing with teachers using student names; 13 statements were developed with a YES/NO scale and three statements had the student explain their answers. The survey was pilot tested and deemed valid and reliable. From the survey data it was found that 97% of the males and 98% of the females stated that the PE teacher knew the student's name. Data indicating that PE teachers using students' names was a form of showing that they cared for their students showed 86% for males and 96% for females. From the qualitative data, student statements regarding the PE teacher knowing student names included, "Because he knows my name, I am willing to participate," and "My name is Marjorie and I go by Scout, and she makes sure to call me by name. I like that." The results indicate that junior high students like when their PE teacher knows and uses their names in class. When a PE teacher uses a student's name, it shows the student that the PE teacher knows and cares for them. A typical PE class has 35 to 40 students; multiplied by 7 classes and a PE teacher has 280 to 320 student names to learn. This may be daunting, yet when a PE teacher learns and uses student names, it can strengthen teacher/student relationships and make a student's PE experience more enjoyable.

Attitudes Matter When Including and Mentoring Students with Physical Disabilities

Aubrey Shaw & Sharon Kay Stoll (University of Idaho)

Unfair discrimination and justified exclusion lead students with physical disabilities to have negative experiences in physical education and sport. Additionally, many students with physical disabilities are not mentored in physical education or sport because of negative attitudes toward the population. However, laws do exist which supposedly demand inclusion of students with physical disabilities. Michael Oliver, a researcher in disability studies, discusses the treatment of students with physical disabilities by larger institutions. He argues laws are there but there is something amiss with societies' attitudes because students with physical disabilities are being excluded and the powerful people within the institutions allow it to occur. Oliver further argues that the able-bodied population may not understand their own biases towards this population. Laws are often maneuvered by leaders to exclude students with physical disabilities. Merleau-Ponty, a philosopher and educator, stated we perceive the world through our own lived bodily experience. Thus, able-bodied individuals may hold a bias because of their own notion of what the population can or cannot do. Assuming most leadership teams are composed of the able-bodied, what can change their attitudes towards this population? The purpose of this philosophical presentation is threefold: 1) to examine how people who are able-bodied are limited because of their own bodies, 2) to discuss how attitudes and biases toward students with physical disabilities affect the mentoring process for these individuals, and 3) to provide solutions for changing attitudes towards students with physical disabilities so they can be mentored and successful.

Assessment in Physical Education: Using a Programmed Practice Sheet

Sarah Ridge, Josie Donohoe, & Keven Prusak (Brigham Young University)

This presentation describes the conceptual and theoretical frameworks for the development of an alternative form of assessment in physical education (PE). It has long been argued that PE teaches to all three domains, namely psychomotor, cognitive, and affective. Yet, there are very few assessment tools to do much more than fitness testing. Psychomotor tests (e.g., skill and fitness testing) are most often not based in evidence but rather are arbitrary in their design. For example, students must complete eight of ten free throws to receive an A-grade in basketball. Other unsupported grading practices purport to grade on such vague ideas as participation, effort, and improvement but lack any actual instrumentation to measure those three ideas. If assessments are used, they are exclusively summative, conducted at the conclusion of the unit and therefore ignore the formative, and focused on the product not the process. The Programmed Practice Sheet is an assessment approach that addresses all three learning domains, is grounded in theoretical and conceptual literature, and focuses on daily participation, effort, and improvement—assessing and rewarding the process. This approach demonstrated beneficial motivational effects in secondary education PE. It allows students autonomy to self-assess and self-select an appropriate level of attainment by balancing workload and degree of challenge in a process of repetition and refinement. It is a student-driven and student-managed tool that unburdens teachers and allows them increased interaction with students.

Advancing Equity in Physical Activity Promotion Material Through Direct Measure of Comprehension: An Efficacy Study

Jafra D. Thomas, Jasmine C. Wong, Regina F. Hockert, Yi Sheng Wu, & Solana Martin (California Polytechnic State University, San Luis Obispo); Zachary Zenko (California State University, Bakersfield)

The purpose of this presentation is to report efficacy results from an ongoing replication study directly investigating physical activity promotion (PAP) material comprehensibility, an area with limited research. The cloze procedure was applied to mock PAP materials developed through previous research using the SMOG formula, written at an 11th (typical) or 8th (maximum recommended) grade reading level (GRL). Without crossover, undergraduates from one California university participated in one of two studies (September 2022–April 2023): (a) an initial pilot study (lab volunteer group) or (b) a subsequent subgroup study (randomly sampled from an ongoing replication study). Per pilot test results, the 8th GRL material required revision. Data were collected through online survey. Reliability was measured using first-author coding for the subgroup study over a 3-day grace period. Twenty-two undergraduates participated (pilot = 12, subgroup = 10). Test instruments had excellent intra-rater reliability. Pilot results contradicted expectations, with 8th GRL material having less comprehension ($p = .02$, $g = 1.94$). Both studies showed 11th GRL material required supplemental instruction ($p < .001$, $g = 2.98$). Edits resulted in 8th GRL material with greater comprehension ($p < .001$, $g = 6.89$) and without needing supplemental instruction ($p <$

.001, g = 2.71). The findings further evidenced that PAP material is often written at an inadequate level for public and client dissemination, and further signify the need to pilot test material written at recommended levels to ensure full comprehension without supplemental instruction.

Good Governance Suggestions to Leaders of America's Pastime: Analyzing Signs of Institutional Progress on the Issue of Minor League Pay Using Historical and Philosophical Perspectives

Mia I. Napolitano & Jafra Thomas (California State University, San Luis Obispo)

Baseball is often depicted in a celebratory light; yet, minor league baseball players have faced wage inequities for many years. At the end of 2022, these injustices saw progress within the institution itself, where the Major League Baseball Player Association was granted legal permission to represent minor league players vis-à-vis its collective bargaining agreement (CBA). The present study builds on previous work by one faculty-undergraduate student dyad analyzing the minor league pay debate. The purpose of the present study was to discern next-step recommendations for good governance using ancient philosophical perspectives. A descriptive qualitative analysis was performed using philosophical perspectives specific to leadership and good governance (e.g., Aristotle's just law treatise). Descriptive review of the academic and popular press literature was performed (April–May 2023) to provide, for critical analysis, a timeline of (a) key historical points leading to the present-day minor league pay debate, (b) changes to MLB policy following social and legal pressures, and (c) MLB rhetoric before and after the CBA. A succinct timeline was produced, showing legal and social challenges to MLB labor policy. Timeline analysis elucidated ways MLB management fell short of good governance, or pushed against it, historically. The findings revealed ways the CBA changes represent positive institutional change but still fall short of redeeming the MLB. Study findings further demonstrate the relevance of applying philosophical perspectives to sport history research for understanding and critiquing moral issues in sport.

Building Up Cal Poly Global Brigades Student Group: Reflections on Designing and Implementing One Undergraduate-Led Community Info Session

Caroline Smith & Jafra Thomas (California State University, San Luis Obispo)

Global Brigades, an international non-profit organization, trains college students and other pre-professionals in community-based health promotion by mobilizing international community service trips taught and led by local community-based organizations and coalitions. The Global Brigades student group at one California State University was founded in 2018 and has carried out three annual, medically-focused brigades to Honduras (two in-person, one virtual). The aim of this talk is to present the findings of one senior project to promote the Global Brigades student group (January–March 2023). The student (first author) designed material for an interactive info session on the group, promoted the event, and appraised the info session efficacy to (a) teach what Global Brigades is and (b) spur interest to join the next student group brigade to Honduras (Summer 2023). Recruitment efforts occurred in partnership with health-based campus groups. Results: The student delivered two 50-minute informational sessions to a total of 16 people, 10 of whom were not previously involved with Global Brigades. A review of open-ended pre-post info session questionnaire responses showed that the session was successful in meeting its objectives. Additionally, the 2023

brigade was the largest in-person brigade that the student group had to date, with 15 students registered. The authors highlight ways the senior project achieved university, department, and program learning objectives for the Bachelor of Science degree in Public Health.

Self-Presentation in a Pandemic: Female Olympic Track & Field Athletes' Use of Instagram During COVID-19

Heather Van Mullem (Lewis-Clark State College)

New media is changing the way athletes are marketing themselves and their careers. The power to create content is especially impactful for athletes who do not receive consistent and/or frequent coverage in mainstream sports media. Guided by Goffman's (1959) self-presentation theory, the purpose of this study was to examine how female Olympic track and field athletes ($n = 15$), competing in short-distance, long-distance, or throwing events, used Instagram to create and manage their presentation of self during a global pandemic. Utilizing methodology in Geurin-Eagleman & Burch's (2016) work, the last 100 photos from each athlete's account were coded using multiple variables measuring the content of each photo (i.e., personal life, professional life, etc.) and interactions with fans (i.e., number of comments). In addition, the frequency of posts which focused on the influence of the global pandemic on their lives in and out of sport was measured. This presentation will: 1) share the findings of this study, 2) compare and contrast the results to previous research findings regarding female athletes' self-presentation through Instagram, and 3) explore the influence of a global pandemic on athletes' posts and self-presentation.

Asking Questions in Class

Gioella Chaparro (California State University, Dominguez Hills)

Silence in the classroom after a professor says "Does anyone have questions?" is a phenomenon that occurs too often. The purpose of this study was to examine how often students ask or do not ask questions, and the reasons why. Ninety-seven Kinesiology undergraduate students (49 males, mean age 24.2 ± 6.2 years) participated in the study. Participants answered Likert-scale questions (i.e., how often they are confused and ask questions, and ranking reasons for such behavior) and a short answer question: "Explain one thing or action that can be taken to help initiate you or your classmates to ask questions when confused in class." ANOVA with a Bonferroni correction examined the ranked reasons. Short answer responses were separated into common themes. Eighty-two percent of students reported being confused "sometimes"; 43% of this group only asked for clarification "sometimes." There were significant differences between the ranked reasons for not asking questions ($p < .05$), with "professor attitude" and "previous negative experiences" being the most significant reasons. From the common themes, the majority of students suggested working in small groups to ask questions among their peers. Most notably, students suggested providing a system to anonymously ask questions and creating a safe space in the classroom. Findings shine light on how often students are confused in class and do not seek clarification. Most importantly, findings provide options for faculty to incorporate into their classrooms.

Student and Faculty Poster Session

#	Poster Title	Type	Author(s)
1	Women's Narratives of Sport Uniforms	Faculty	Elaine Foster (Idaho State University)
2	How Did Residential Environments Impact Older Rural Adults' Physical Activity Levels During the COVID-19 Pandemic?	Faculty	Minyong Lee, Sung-Jin Lee, & Sheryl Robinson (North Carolina A&T State University)
3	Antitrust Jurisprudence, Global Monopoly, and Future of Professional Golf Tournaments	Faculty	Sungho Cho (Bowling Green University) & Minyong Lee (North Carolina A&T State University)
4	Effectiveness of Marketing Strategies to Increase PETE Enrollment	Faculty/Student	Todd Pennington, Zack Beddoes, Ashley Zundel, & Taleni Ta'ase (Brigham Young University)
5	Collegiate Pre-Service Teacher's Experiences and Perception in the Sport Education Model: An Application to Teaching Tennis	Faculty	Boung Jin Kang (Elizabeth City State University), Minhyun Kim (Sam Houston State University), & Yoonsin Oh (University of Wisconsin–Eau Claire)
6	Effect of Early Surgery vs. Physical Therapy on Knee Function (Article Critique)	Student	Nadine Casias & Gioella Chaparro (California State University, Dominguez Hills)
7	PETE Majors' Perceptions of Participating in a Semester-Long High School Physical Education Practicum (Original Research)	Student	Karina Bues, Jack Stalnaker, Brandon Weekes, & David Barney (Brigham Young University)

#	Poster Title	Type	Author(s)
8	Plans to Ignite Inclusive Dialogue on Gender Issues in Sport Coaching & Administration: A Progress Report (Original Research)	Student	Brendan Carter & Jafra Thomas (California State University, San Luis Obispo)