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Original Research

The Effect of Static Stretching, Mini-Band Warm-Ups, Medicine-Ball Warm-Ups, and a Light Jogging Warm-Up on Common Athletic Ability Tests

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ABSTRACT

International Journal of Exercise Science 13(4): 298-311, 2020. Proper warm-up is important for facilitating peak athletic performance and reducing injury risk; yet, warm-up procedures vary considerably amongst coaches and athletes. The purpose of this study was to assess the effect of a static stretching, medicine-ball, and mini-band warm-ups relative to a light jogging warm-up only on athletic ability test performance. It was hypothesized that static stretching would negatively affect performance, while medicine-ball and mini-band warm-ups would positively affect performance relative to light jogging only. Twelve female collegiate soccer players (19.3 ± 1.2y, 65.2 ± 7.5kg, 1.67 ± 0.07m) participated in this study. Athletes completed each warm-up protocol and all of the athletic performance tests over four sessions in a semi-randomized, counterbalanced order. An omnibus MANOVA with vertical jump height, medicine ball throw distance, 10m and 20m sprint time, and T-test time as the dependent variables was not significant indicating that warm up did not have an effect on subsequent athletic ability test performance [Wilks' $\lambda = 0.64$, $F(15,110) = 1.28$, $p = 0.23$, $\eta^2 = 0.14$]. Static stretching warm-up did not negatively influence athletic potential compared to mini-band and medicine ball warm-ups, though the most optimal warm-up is likely athlete specific.

KEY WORDS: Soccer, athletic performance, vertical jump, short sprints, medicine ball throw

INTRODUCTION

The primary purposes of a warm-up are to prepare the body for high intensity exercise in an effort to optimize athletic performance and reduce the risk of musculoskeletal injury (5-7). While a warm-up is considered vital and performed frequently by many coaches and athletes, there is no universally accepted method (5-7). The methods used are typically based on the coach or athlete's experience with a given warm-up and their perception of its effectiveness; thus, the duration, intensity, and modes of exercise used in a warm-up can vary considerably (5-7). While the definition of an optimal warm-up is elusive and most likely individual specific, the overarching recommended warm-up model progresses from general exercise to sport-specific movement (5-7). This model may include short durations of low intensity aerobic exercise such as jogging or cycling, various forms of stretching, and movements that mimic the activity the athlete will subsequently engage in (5-7). Unfortunately, many athletes fail to complete each aspect of this progressive model and heavily favor just a single component. This leads to an incomplete warm-up that can undeniably influence athletic performance (16).

Stretching can take many different forms including passive or static stretching (SS), active or dynamic stretching (DS), ballistic, and proprioceptive neuromuscular facilitation (5-7, 26). SS is likely the most commonly performed mode of exercise during a warm-up, potentially due to its accessibility and familiarity amongst coaches and athletes (5-7). SS involves passively moving a joint into its end range of motion (ROM) and holding this position for given duration of time (5, 21). Some of the presumed benefits of SS prior to athletic participation include increased reach and decreased resistance to movement due to more compliant musculotendinous unit (5, 21). It has been demonstrated that acute and chronic bouts of SS are effective at increasing ROM (14); though, increases in ROM are likely due to an increase in stretch tolerance and not due to changes in the viscoelastic properties of the musculotendinous unit (24).

While acute increases in ROM may be advantageous for sports that require high ROM for success (e.g. gymnastics, diving), a number of studies have demonstrated SS transiently reduces the rate and magnitude of skeletal muscle force production (3, 30, 39). Proposed mechanisms for the decrement in skeletal muscle force generation are that SS temporarily reduces musculotendinous unit stiffness and neural drive (22, 33). Ultimately, this may place an athlete at a short-term disadvantage in activities that require skeletal muscle to develop large amounts of force rapidly (e.g. weightlifting, sprinting). In fact, it has been demonstrated that professional male soccer players who are relatively less flexible than their peers have greater muscular stiffness, which is associated with better performance during some anaerobic fitness tests (31). It has also been revealed that greater volumes of SS have a larger negative effect on subsequent anaerobic fitness test performance compared to smaller volumes of SS (32, 38). Furthermore, there is little evidence to support the relation between SS and injury risk reduction despite popular belief (29, 37). If SS were performed in isolation as the only component of warm-up, it is highly likely that the individual would not elicit additional physiological changes associated with DS (5-7). These changes, such as increased core and muscle temperature, heightened peripheral blood flow, and greater cardiorespiratory and metabolic activity compare to at rest are highly important in facilitating peak performance (5-7).

The overwhelming consensus is that a warm-up consisting of DS, which may or may not include equipment (e.g. medicine ball, mini-band), are more beneficial than SS prior to anaerobic fitness tests (1, 2, 5, 9, 12, 15, 17, 19, 23, 26, 27, 31, 39). DS involves controlled movements through a joint's active range of motion. Although variations exist, most DS warm-ups feature progressive, continuous movements such as squatting, lunging, skipping, and multi-direction running drills. Importantly, this type of warm-up likely elicits the aforementioned physiological changes that are beneficial for peak performance. Furthermore, some of the exercises performed and implements used as part of DS warm-ups may share similarities with the exercises performed as part of common injury prevention and plyometric training regimens (4, 8, 12, 13, 27, 34).

A proper warm-up is an important contributor to subsequent athletic success. While SS is performed frequently as part of a warm-up, it may not be as beneficial as once presumed. DS is an integral part of present-day warm-ups, though the effectiveness of DS at eliciting peak performance during anaerobic fitness tests is unclear. Thus, the purpose of this study was to examine the effect of a SS warm-up and two different DS warm-ups that utilized a medicine ball and mini-band, respectively, on athletic ability test performance in college aged female soccer players compared to a light intensity jogging warm-up only. It was hypothesized that the DS warm-ups would positively influence athletic ability test performance while SS would negatively influence anaerobic fitness test performance.

METHODS

Participants
A convenience sample of 24 healthy, NCAA Division I women's soccer players were recruited to participate in this study (19.3 ± 1.2 years, 65.2 ± 7.5 kg, 1.67 ± 0.07 m). This sample was chosen because all of the athletes had similar exposure to the same resistance training techniques. They also were generally familiar with the exercises used in the warm-ups in this study because they were regularly completing comparable warm-up sequences and athletic ability tests with their strength and conditioning coach. During this study's data collection time frame the athletes were in the off-season training phase. However, they did compete in some competitions that did not count towards their win-loss record. During this off-season phase they were resistance training three days per week and completing speed and agility training two days per week. Extramural physical activity was not recorded. Athletes with a history of significant knee injury in the past year as well as those withheld from athletic participation by the athletic training staff at the time of enrollment were excluded from the study. The athletes were given a participant number and then randomly assigned into four groups using a table of random numbers from a statistical book. The first participant number that came up was in the first group, second participant number that came up was in the second group, and so on. They were then assigned a counterbalanced warm-up order to perform over the course of the study's four testing sessions (Table 1). Some players were unable to complete all four testing sessions due to injuries that occurred between testing sessions. Twelve athletes completed all four days of testing. This research was carried out fully in accordance to the ethical standards of the International Journal of Exercise Science (25). The North Dakota State University Institutional Review Board approved this study's protocol and all athletes provided their informed, written, voluntary consent to participate. None of the athletes were less than 18 years old.

Table 1. Semi-randomized, counter balanced warm-up protocol prescription.

Group	Session 1	Session 2	Session 3	Session 4
1	Mini-Band	Medicine Ball	Static Stretching	Control
2	Medicine Ball	Mini-Band	Control	Static Stretching
3	Static Stretching	Control	Medicine Ball	Mini-Band
4	Control	Static Stretching	Mini-Band	Medicine Ball

Protocol
This study used a semi-randomized, counterbalanced, cross-over design to investigate the effect of four different warm-up protocols on anaerobic fitness test performance. The warm-up protocols included pre-determined prescriptions of SS, DS with a medicine ball (MED-BALL), DS with a mini-band (MINI-BAND), and control (CON). Athletic ability tests included vertical jump, 20m sprint with 10m split, T-test, and a medicine ball throw. Athletes attended five scheduled sessions. During visit one, investigators outlined the procedures and schedule for the remaining four sessions. Athletes then completed each warm-up protocol over visits two through five in a semi-randomized, counterbalanced order. During each of these visits, the athlete performed all five of the athletic ability tests in a semi-randomized, counterbalanced order.

The warm-up protocols used in this study were chosen in order to simulate frequently used warm-up procedures by athletes and because they utilized accessible pieces of equipment that could be used during warm-up (Table 2). The stretches performed as SS were chosen to mimic some of the common stretches performed by athletes. Stretches were held for 15 seconds per side, and athletes were instructed to stretch until they felt light discomfort. MINI-BAND was chosen because a common theme of injury prevention programs is the concentrated effort on gluteal activation, often using an elastic mini-band positioned around the knees or ankles (34). It has been demonstrated that low load gluteal activation exercises completed as part of a warm-up prior to athletic ability tests enhance performance (12, 27). MED-BALL was chosen because it provided an external load, could be used to perform plyometric exercises, and could be moved around the athlete's body challenging various stabilizing muscles. It has been revealed that warming-up with an external load, frequently in the form of a torso worn weight vest, as well as completing plyometric exercises improves subsequent athletic ability test performance (4, 8, 13). Due to the large number of exercises assigned as part of the warm-up protocols in this study, it is beyond the scope of this paper to address the proper technique or progression for each them.

Testing sessions took place over the course of two weeks at the same time of the day with at least 48 hours between sessions. Athletes arrived at the testing facility in two flights, 30 minutes apart to ensure that each participant had a standardized amount of time between assessments. The warm-ups were supervised by the investigators to ensure that each group used proper technique for all of the exercises. Each warm-up protocol started with a five-minute, light intensity jog, with CON completing only this jog on the appropriate day of testing. Since MED-BALL, MINI-BAND, and SS took approximately another five minutes to complete after the jog, CON did not start the jog until after the other groups were done with the jog. This allowed all groups to complete their warm-up at approximately the same time to ensure that they began testing simultaneously. The vertical jump, medicine ball throw, 20m sprint with 10m split, and T-test assessments were completed at four different testing stations around the facility in a semi-randomized, counterbalanced order (Table 3). After the completion of the warm-up, the athletes had two minutes to proceed to the correct testing station as well as two minutes between the completion of each test.

Table 2. Warm-up protocols.

CONTROL	Five-minute jog only.	
MINI-BAND	Five-minute jog. Band Above Knees: Bodyweight squats	10 repetitions
	Band Below Knees: Monster walks, Over-stride slide	10m down and 10m back
	Band Around Ankles: Straight leg walks forward & backwards, straight leg walks lateral	10m down and 10m back
	Band Around Feet: Hip flexion, Hip rotation	8 repetitions to each side
MEDICINE BALL	Five-minute jog. Counterbalanced squat, Overhead chops, Floor pass, Counterbalance Romanian deadlift (RDL)	10 repetitions
	Forward lunge with twist over knee, Side slams, Reverse lunge with bend over knee	5 repetitions to each side
STATIC STRETCHING	Five-minute jog. Groin, Hip flexor, Lunge, Lying glute, Lying knee extensor, Seated knee flexor, Standing gastrocnemius, Arm across body, Arm behind head	15 seconds for all stretches

Vertical Jump: Maximal vertical jump height was assessed because it is commonly used to estimate an individual's lower-extremity power capacity (18). Athletes were instructed to perform a countermovement vertical jump on a three-dimensional force plate (AccuPower, Advanced Medical Technology Inc., Watertown, MA, USA) sampling at 1,200 Hz. Jump height was calculated by the AccuPower software. Three trials were completed, and the highest jump was used for analyses.

Table 3. Semi-randomized, counter balanced athletic ability test order for each of the testing sessions.

Group	Session 1	Session 2	Session 3	Session 4
1	MB THOW, 20M, VJ, T-Test	20M, MB THOW, T-Test, VJ	VJ, T-Test, MB THOW, 20M	T-Test, VJ, 20M, MB THOW
2	20M, MB THOW, T-Test, VJ	MB THOW, VJ, 20M, T-Test	T-Test, 20M, VJ, MB THOW	VJ, T-Test, MB THOW, 20M
3	VJ, T-Test, MB THOW, 20M	T-Test, 20M, VJ, MB THOW	20M, MB THOW, T-Test, VJ	MB THOW, 20M, VJ, T-Test
4	T-Test, VJ, 20M, MB THOW	VJ, T-Test, MB THOW, 20M	MB THOW, VJ, 20M, T-Test	20M, MB THOW, T-Test, VJ

MB Throw = overhead medicine ball throw for distance, 20M = 20m sprint, 10M = 10m sprint, VJ = vertical jump

Medicine Ball Throw: The medicine ball throw was chosen because it is commonly used to evaluate total body power capacity (35). A tape measure was secured to the floor with its zero-mark parallel with a line drawn on the floor. Athletes were instructed to stand on the zero mark with the ball extended out in front of them followed by a countermovement. Athletes then threw the four kg medicine ball backwards, overhead. Throw distance was measured from the zero line to the location the medicine ball landed using the tape measure. Three trials were completed, and the farthest throw was used for analyses.

10m and 20m Sprint: Linear sprint speed was assessed because it is highly valued in a variety of sports including soccer (17). The sprints were timed using a single photocell timing system (Brower Speed Trap 2, Brower Timing Systems, Draper, UT, USA). Athletes were instructed to line up on the start line in a two-point runner's stance and begin their maximal effort sprint when they felt comfortable. Timing was manually initiated by an investigator aligned parallel with the sprint start line at the first sign of the athlete's movement. Photocell transmitters and corresponding receivers were setup approximately 3.05m apart, perpendicular to the sprint line at the manufacturers recommended height off the floor at 10m and 20m. Three trials were completed, and the fastest 10m and 20m times were used for analyses; though, the time used for each distance was not necessarily from the same sprint trial.

Agility: Agility was assessed using the T-test test because change of direction ability is highly valued in a variety of sports including soccer (2). The T-test tests were timed using a single photocell timing system (Brower Speed Trap 2, Brower Timing Systems, Draper, UT, USA). Three cones were setup on a parallel line 5 yards (4.6m) apart from each other, and a fourth cone was setup 10 yards (9.1m) from the middle cone forming a "T". The athletes were instructed to start at the bottom of the "T" on the start line in a two-point runner's stance and begin their maximal effort sprint when they felt comfortable. The athletes then sprinted straight ahead 10 yards to the middle cone, shuffled 5 yards to the right cone, shuffled 10 yards to the far-left cone, shuffled 5 yards to the right to the middle cone, then backpedaled 10 yards through the start cone to finish. Timing was manually initiated by an investigator aligned parallel with the sprint start line at the first sign of the athlete's movement. Photocell transmitters and corresponding receivers were setup approximately 3.05m apart, parallel with the start line at the manufacturer's recommended height off the floor. Three trials were completed, and the fastest time was used for analyses.

Statistical Analysis

A statistics program (IBM SPSS Statistics v.22, Chicago, IL, USA) was used to calculate descriptive statistics including means, standard deviations (SD), 95% confidence intervals (CI), and standardized scores (z-scores). Z-scores for the five athletic tests were computed individually for each athlete using the raw results from the four testing sessions. For example, the four vertical jump results for an athlete were used to convert the raw vertical jump results in to standardized results for that athlete, and this process was completed for the remaining four tests for all of the athletes. This meant that z-scores less than zero reflected a better performance than that athlete's average on the 10m sprint, 20m sprint, and T- agility test while a z-score greater than zero reflected a better performance than that athlete's average on the vertical jump and medicine ball throw. To facilitate the ease of comparisons between the five tests, the z-scores for the 10m sprint, 20m sprint, and T-test test were inverted so that positive z-score indicated better performances on average for all five of the tests. Computing the results in this fashion allowed for direct comparisons of the magnitude of the effect of the warm-up on performance between athletes while accounting for differences in general athletic talent between athletes. The within-day reliability of the five fitness tests used in this study were computed using the raw results from the three trials completed during CON and reported as typical error, a measure of absolute reliability (11, 20). Relative typical error was calculated by dividing the typical error by the cohort's mean raw score from the three trials completed during CON and reported as a percentage.

Box's M Test and Levene's Test were used to evaluate the equality of the dependent variables' variance and covariance matrices. A multivariate analysis of variance (MANOVA) was used to determine the effect of the independent variable of warm-up on the athletic performance standardized dependent variables of vertical jump height, medicine ball throw distance, 10m and 20m sprint time, and T-test time. Follow-up univariate and Bonferroni corrected pairwise comparisons were used where appropriate. The critical value was initially set to $p < 0.05$ for all statistical tests. Effect size was calculated using partial eta squared (η^2) where a value greater than or equal to 0.26 represents a large effect, a value between 0.13 and 0.25 represents a medium effect, and a value between 0.02 and 0.12 represents a small effect (10).

RESULTS

The within-day typical error for the vertical jump, medicine ball throw, 10m and 20m sprint, and T-test completed during CON were 0.011m, 0.55m, 0.10s, 0.33s, and 1.39s, respectively. This led to a relative typical error of 4% for vertical jump, 8% for medicine ball throw, 5% for 10m sprint, 8% for 20m sprint, and 12% for T-test.

An omnibus MANOVA with standardized vertical jump height, medicine ball throw distance, 10m and 20m sprint time, and T-test time as the dependent variables was not significant indicating that warm up did not have an effect on subsequent anaerobic fitness test performance [Wilks' $\lambda = 0.64$, $F(15,110) = 1.28$, $p = 0.23$, $\eta^2 = 0.14$] (Table 4)(Figure 1 and 2).

Table 4. Mean ± standard deviation for the raw scores for the athletic ability tests following mini-band, medicine ball, static stretching, and control warm-ups.

	CON	SS	MINI-BAND	MED-BALL
VJ (m)	0.34 ± 0.03	0.32 ± 0.03	0.33 ± 0.04	0.33 ± 0.03
10M (s)	2.04 ± 0.08	2.08 ± 0.08	2.12 ± 0.10	2.09 ± 0.08
20M (s)	3.50 ± 0.11	3.54 ± 0.11	3.56 ± 0.14	3.53 ± 0.13
T-Test (s)	10.73 ± 0.47	10.68 ± 0.59	11.05 ± 0.81	11.07 ± 0.62
MB Throw (m)	7.12 ± 1.04	7.19 ± 0.98	6.94 ± 0.85	6.85 ± 0.96

MB Throw = overhead medicine ball throw for distance, 20M = 20m sprint, 10M = 10m sprint, VJ = vertical jump, CON = control warm-up, SS = static stretching warm-up, MINI-BAND = mini-band warm-up, MED-BALL = medicine ball warm-up.

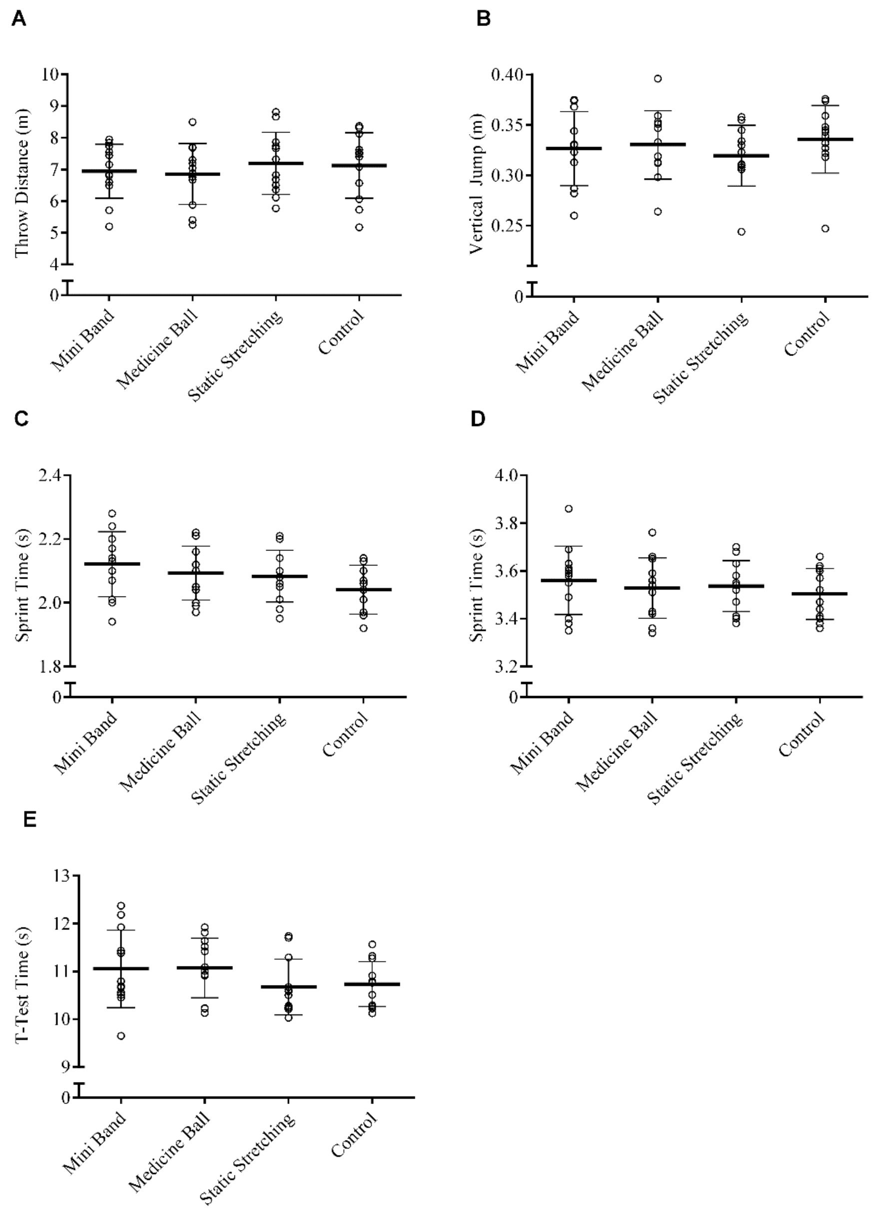

Figure 1. Medicine ball throw (A), vertical jump (B), 10m sprint (C), 20m sprint (D), and T-test (E) performance following mini-band, medicine ball, static stretching, and control warm-ups. Clear circles: individual athletes; solid bars: condition mean; whiskers: standard deviation.

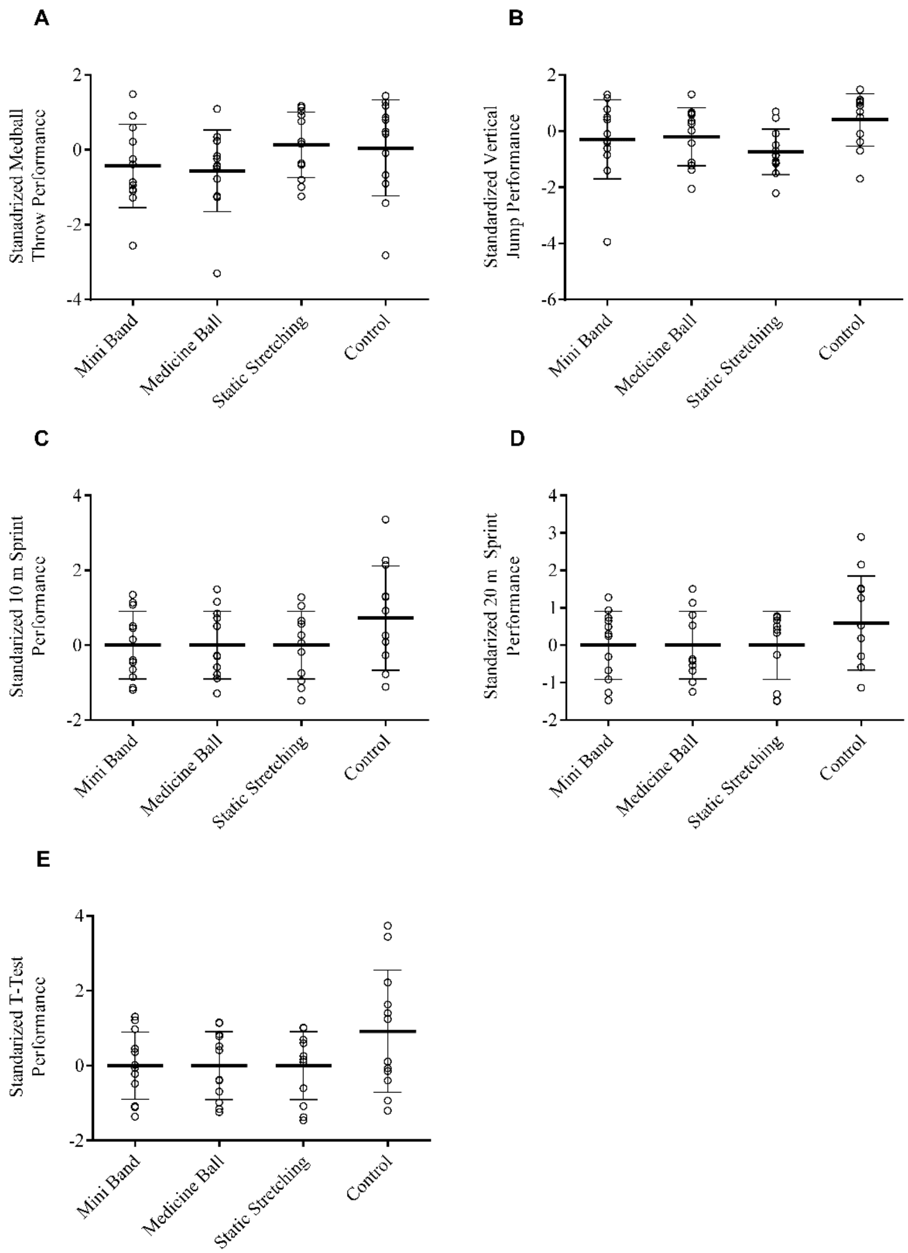

Figure 2. Standardized medicine ball throw (A), vertical jump (B), 10m sprint (C), 20m sprint (D), and t-agility (E) performance following mini-band, medicine ball, static stretching, and control warm-ups. Positive values indicate better than average performance while negative values indicate worse than average performance. Clear circles: individual athletes; solid bars: condition mean; whiskers: standard deviation.

DISCUSSION

While a warm-up is considered vital by many coaches and athletes, the intensity, duration, and modes of exercise can vary considerably (5-7). SS is performed with high frequency despite growing evidence of its ineffectiveness at eliciting peak performance during athletic ability tests, while DS is emerging as a more viable and effective alternative (1, 2, 5, 9, 12, 15, 17, 19, 23, 26, 27, 31, 39). Thus, the purpose of this study was to assess the effect of SS, MED-BALL, and MINI-BAND compared to CON. It was hypothesized that SS would have a negative effect on subsequent athletic ability test performance while MED-BALL and MINI-BAND would have a positive effect on subsequent tests.

An important finding of this study was that warm-up did not have an effect on athletic ability test performance. Specifically, SS did not produce a decrement in performance as hypothesized. Research examining the effectiveness of SS warm-ups on athletic ability test performance in soccer players has demonstrated that SS is either detrimental or not detrimental to performance, but not beneficial (1, 2, 17, 23, 26). While these investigations revealed that DS is the preferred method, some recommended that if SS was performed it should be limited to short durations (23). Research has demonstrated that there is a volume effect of SS in which decrements are more pronounced with longer stretching durations (32, 38) In the present study, it is possible that SS decrements in anaerobic fitness test performance compared to CON may have been elucidated had the athletes held each stretch for a longer duration. It has also been recommended that if SS is performed, additional DS should be performed afterwards to attenuate the decrease in athletic ability test performance caused by SS (23, 33) though, other research has indicated that additional DS after SS does not negate the negative effects of SS (28).

MINI-BAND and MED-BALL also did not lead to better performance as hypothesized. This may be because they lacked progression in intensity, meaning some of the physiological changes achieved by MINI-BAND and MED-BALL may have been comparable to CON. CON consisted of only a five-minute jog, which may have adequately increased core and muscle temperature, cardiorespiratory and metabolic activity, and peripheral blood flow. Had MINI-BAND and MED-BALL progressed in intensity to match the intensity of the subsequent athletic ability tests, it is possible improvements in performance would have been achieved.

Compliance amongst injury prevention programs is generally low (36). It is plausible that this is because coaches and athletes do not find these programs time efficient or effective at eliciting peak performance in the ensuing athletic bout. Perhaps to increase compliance, a program may need to demonstrate effectiveness at both. Research has demonstrated that low load gluteal activation exercises similar to those completed during MINI-BAND lead to improvements in athletic ability test performance (12, 27). The results of this study seem to suggest that while MINI-BAND did not improve subsequent performance, it did not harm it either. This likely does not offer support strong enough to encourage complete adherence, but it is promising, and additional research is warranted in this area.

Research has demonstrated that completing a warm-up with a weighted object, such as dumbbells or a weighted vest, improves subsequent athletic ability test performance. Burkett et al. (2005) demonstrated that when athletes performed weighted submaximal vertical jumps prior to vertical jump testing, athletes were able to jump higher (8). In the present study, none of the exercises performed during MED-BALL were identical to the athletic ability tests as is the case with the protocol of Burkett et al. (2005), which may be one reason that MED-BALL did not lead to improvements in performance (8). Furthermore, while jumping exercises are a common component of a plyometric regimen, MED-BALL did not incorporate any jumping exercises (4, 13).

The athletes in this study were practicing and competing in soccer during the two weeks that this study took place, and factors such as nutrition, hydration, and sleep were not controlled for during the study. While this may have impacted the results, there was a tradeoff between controlling for these variables and testing these athletes during real-world competition and practice. Since these were NCAA Division I student-athletes, proper nutrition, hydration, and recovery are stressed by all members of the athletic department. Nevertheless, coaches need to be cognizant of their team's overall condition and may need to adjust the intensity, duration, and modes of exercise performed during the warm-up. Simply, if residual fatigue is present it may be appropriate to lower the intensity and duration of the warm-up, so a theoretical threshold is not crossed in which the warm-up goes from being beneficial to fatiguing.

The optimal warm-up is likely athlete specific. This is apparent when the standardized effects of the warm-up on performance are examined. For several tests, the mean standardized performance is close to zero with the whiskers and individual athlete data points extending into regions associated with better and worse than average performances (Figure 2). This indicates that the aggregation of individual participant performances often masks between warm-up condition effects when mean data are compared. For every athlete that performed better than average following a given warm-up, another athlete performed worse than average. Although warm-up has a positive effect on a number of physiological factors, the psychological mechanisms that facilitate peak performance cannot be ignored (6). Despite its intangible nature, athletes may perceive that a certain mode of exercise prepares them best, and this perception may ultimately be just as important as the physiological response the warm-up produces.

This study is limited by a small sample size and lack of inclusion of athletes of other sports, which decreases its power and generalizability. The warm-ups utilized in this study may have been associated with reduced musculoskeletal injury risk compared to other warm-up protocols if performed routinely prior to athletic participation (34), though injuries were not prospectively tracked in this acute response study. Lastly, specific athletes may have had preconceived perceptions of each warm-up's effectiveness that may have psychologically affected their subsequent performance; however, these perceptions were not measured. Future research should incorporate athletes from multiple sports and the assessment of the athletes' psychological perceptions of the effectiveness of various warm-up routines.

Proper warm-up prior to engaging in athletics is vitally important in facilitating peak performance and reducing the risk of musculoskeletal injury. The results of this study seem to suggest that SS, MED-BALL, and MINI-BAND did not affect subsequent anaerobic fitness test performance any differently compared to CON. While SS did not detrimentally affect subsequent performance, DS warm-ups are most likely the preferred warm-up method. Athletic coaches must be cognizant of their athletes' condition. During phases of training and competition in which overtraining may be occurring, the intensity and duration of the warm-up should be lowered so that the warm-up itself does not cause additional fatigue prior to the athletic bout. Ultimately, the most optimal warm-up is likely athlete specific. Allowing responsible athletes to choose their warm-up may facilitate the highest levels of athletic performance.

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