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Training Specificity and Functional Performance in Collegiate Cheerleaders

Carly Routman

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TRAINING SPECIFICITY AND FUNCTIONAL PERFORMANCE IN COLLEGIATE CHEERLEADERS

by

CARLY ROUTMAN

(Under the Direction of Jessica Mutchler)

ABSTRACT

INTRODUCTION: Competitive collegiate cheerleading requires participants to be conditioned for explosive powerful movements. Studies have shown cheerleading is associated with a high incidence of catastrophic injury (Mueller, 2009; Boden, 2005; Xu et al., 2021). In response to high injury rates, studies have recommended strength and conditioning requirements to decrease the likelihood of injury due to the lack of cheer-specific training (Jacobson et al., 2004). Although it has been recommended for cheerleaders to receive formal strength training, many schools do not provide these resources to their cheerleading teams. PURPOSE: The purpose of this study was to determine if there are differences in training specificity within collegiate cheerleaders that lack a formal strength and conditioning program, and to see if those differences in training specificity impact performance on common functional tests measuring balance, strength, muscular endurance, power, agility, and aerobic fitness. METHODS: Participants included 31 collegiate cheerleaders, 7 male and 24 female, between the ages of 18 and 22. All participants completed a training specificity questionnaire and functional testing. The sample was allocated to Anaerobic-focused group (n=16) or Mixed group (n=15) based on their reported training specificity. Multiple independent sample t-tests were used to determine if significant differences existed between groups. RESULTS: The Anaerobic group performed better on the 3-repetition maximum back squat (3RM) and standing broad jump compared to the Mixed group (3RM: Anaerobic: 135.69 ± 31.69, Mixed: 116.33 ± 14.21, p = 0.038, d = 0.84; SBJ: Anaerobic: 203.36 ± 24.1, Mixed: 183.39 ± 15.52, p = 0.011, d = 1.01). CONCLUSIONS: Differences in training specificity do exist within a collegiate cheerleading program that lacks formal strength and conditioning resources, and this difference may influence performance on strength and power functional tests such as the 3RM and standing broad jump.
Compared to normative data, collegiate cheerleaders may still reach average scores on most functional tests regardless of not having a formal strength and conditioning program, but agility and upper extremity muscular endurance may be lacking. Future research should expand on the need for formal strength and conditioning resources in collegiate cheerleading and expand to other cheerleading populations.

INDEX WORDS: Training specificity, Specific adaptations to imposed demand, Strength and conditioning, Collegiate competition cheerleading, Functional performance
TRAINING SPECIFICITY AND FUNCTIONAL PERFORMANCE IN COLLEGIATE CHEERLEADERS

by

CARLY ROUTMAN

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WATERS COLLEGE OF HEALTH PROFESSIONS
TRAINING SPECIFICITY AND FUNCTIONAL PERFORMANCE IN COLLEGIATE CHEERLEADERS

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CHAPTER I
INTRODUCTION

Cheerleading has been around since 1898 when the University of Minnesota organized a team of all male students to encourage their athletic teams (Lord, n.d.). In the 1940s, women were finally permitted to join cheerleading teams (Moritz, 2011). Since then, cheer’s evolution has gone far beyond its initial purpose. Today, competitive cheer teams exist; these groups perform at all levels and are not solely for crowd leading and entertaining fans. Cheerleaders are highly skilled athletes who learn intricate routines that include dancing, jumps, stunts, and tumbling (Zdunek, 2020).

Cheerleading is a physically demanding contact sport. Competitive collegiate cheerleading requires participants to be conditioned for explosive powerful movements packed into a two-minute-and-fifteen-second routine. Participation requires muscular endurance and optimal anaerobic conditioning (Donovan & Spencer, 2019). More specifically, cheerleading can be broken down into several basic biomechanical elements. These include running, jumping, landing, and balancing (Fields et al., 2005; Leitz et al., 2015). Both running and jumping require quick explosive force production, while landing and balancing require more controlled muscle contraction for proper shock absorption (Fields et al., 2005). The metabolic needs of cheerleading during performances fall at the boundary between anaerobic and aerobic processes. (Goodwin et al., 2004). The demand placed on the athletes varies by position and ability. Flyers require more mobility, balance, and body awareness, while bases use more explosive strength and power (Udris, 2013). Both positions are expected to tumble which requires neuromuscular control, full-body strength and power, coordination, and speed (Goodwin et al., 2004; Leitz et al., 2015; Udris, 2013). Resistance to fatigue is important in cheerleading as fatigue has been shown to decrease force production, muscular response time, and trunk stability (Donovan & Spencer, 2019). Therefore, the variety of skills needed by a cheerleader to perform at a high level requires proper, intentional training for a balance of strength, mobility, coordination, and endurance.

Although the demands of cheerleading are well established, cheerleading is not considered a sport by most institutions, but rather an extra-curricular activity (Cheer Union, 2018). Although cheerleading in
general, and collegiate cheerleading specifically, has been growing, collegiate athletic departments have not provided a proportional increase in support and resources. This may hinder coaches’ ability to protect cheerleaders from injury and increase skill difficulty at the same time. Many teams are attempting skills at a high level without proper safety precautions, formal strength and conditioning, or medical coverage (Mueller, 2009). Without the sport designation, there are few mandated training and safety regulations for cheerleading nationally and globally, and as the sport becomes more advanced, the inherent danger also increases (Mueller, 2009). Studies have shown that cheerleading is associated with the highest incidence of catastrophic injury, as well as about half of sport-related fatalities in all sports where females participate (Mueller, 2009; Boden, 2005; Xu et al., 2021). A survey of 425 high school cheerleaders showed that almost 62% of the participants had suffered a cheer-related injury in their career, and nearly 17% reported five or more (Jacobson et al., 2004). In a similar study of 440 collegiate participants, 78% said they had been injured throughout their careers (Jacobson et al., 2005). More specifically, a study from 2009 showed that stunting may account for 60% of cheerleading injuries and up to 96% of cheer-related concussions, while a more recent study shows that injury incidence during stunting has decreased to 22-34% of total cheerleading injuries (Shields et al., 2009; Xu et al., 2021). Injury prevalence lately is shifting towards tumbling being the most frequent cause, as more safety regulations for stunting have been put in place (Xu et al., 2021).

In response to high injury rates, studies have recommended strength and conditioning requirements to decrease the likelihood of injury due to the lack of cheer-specific training (Jacobson et al., 2004). The National Center for Catastrophic Sports Injury Research (NCCSIR) released 15 safety recommendations for cheerleading, most of which harped on proper mechanics, training, and supervision (Mueller, 2009). Although it has been recommended for cheerleaders to receive formal strength training, many schools do not provide these resources to their cheerleading teams. This means that many competitive collegiate cheerleaders are participating in one of the most dangerous sports, without formal conditioning and periodization. The impact of this lack of resources on the physical fitness and functional performance of collegiate cheerleaders is currently unknown. To investigate this further, more research
needs to be done on the effects of not having formal strength and conditioning resources on functional performance as it relates to the demands of cheerleading.

Therefore, the purpose of this study was to determine if there are differences in training specificity within collegiate cheerleaders that lack a formal strength and conditioning program, and to see if those differences in training specificity impact performance on common functional tests measuring balance, strength, muscular endurance, power, agility, and aerobic fitness. The research questions included 1) do differences in training specificity exist within collegiate cheerleaders who lack a formal strength and conditioning program, 2) if differences in training specificity exist, do they affect performance on common functional tests of balance, strength, muscular endurance, power, agility, and aerobic fitness, and 3) do collegiate cheerleaders who lack a formal strength and conditioning program still meet average scores on common functional tests compared to normative data for a physically active population? We hypothesized that differences in training specificity would exist within collegiate cheerleaders who lacked a formal strength and conditioning program, functional testing outcomes would differ between groups with different training specificities, and most collegiate cheerleaders who lacked a formal strength and conditioning program would still meet average scores on common functional tests when compared to normative data for a physically active population.
CHAPTER II

METHODS

Participants

Participants in this study included 31 collegiate cheerleaders, 7 male and 24 female (age = 19.7 ± 1.35 years). All participants were actively on a competitive collegiate cheerleading team with no formal strength and conditioning coach, or like resources provided to them. Exclusion criteria included answering “Yes” to any item on the 2022 PAR-Q+ or being actively withheld from activity due to injury or illness. This study required that all participants answered a questionnaire, informed the investigators of any previous experience with formal strength training, and complete a functional testing battery. An a-priori power analysis was conducted to determine the estimated sample size required in each group to reach 80% power. The results of a previous study comparing the 3-repetition maximum (RM) of groups that completed strength training (82.3 ± 26.4 kg) compared to endurance training (48.3 ± 13.2 kg) was used to complete this analysis (Gavanda et al., 2022). With Cohen’s $d$ effect size of 1.72, less than nine participants in each group would reach estimated power requirements (Cohen, 1988). Although our final group allocations were greater than nine each, the statistical power of our main observations only reached 60-75%. An illustration of the recruitment process can be seen in Figure 1.

One of the investigators was also the current cheerleading coach. This investigator was only involved as a content expert prior to and following the completion of the study. The investigator was not present or a part of recruitment, data collection, or data processing. This study was approved by the University’s Institutional Review Board, and all participants provided their written informed consent before they began the procedures of the study.

Data Collection

Following the collection of informed consent documents, participants completed a short questionnaire describing the physical activity they perform outside of their scheduled cheer practices and events. The goal of the questionnaire was to identify participants’ training specificity for the purpose of splitting the sample into participants who focus mainly on aerobic training methods versus those that
focus mainly on anaerobic training methods, or an equal combination of the two training types (mixed). The questionnaire covered the type, frequency, duration, and intensity of each exercise performed in a typical week outside of cheerleading. For our study, aerobic training methods included continuous tasks that required longer duration of training time, such as long-distance running, rowing, biking, and swimming. Anaerobic training included training methods such as weightlifting, high-intensity interval training, calisthenics, and plyometrics. Questionnaire responses were not analyzed until all data collection for the study was completed.

Prior to the testing sessions, all participants attended a familiarization session where they practiced the testing battery without maximal effort. This was done to ensure that all participants were aware of and comfortable with the testing procedures. Upon the start of the testing session, participants' height, weight, age, resting heart rate, and estimated maximum heart rate were recorded prior to the warm-up and testing. Once these measures had been recorded, participants began by completing the balance assessment, followed by a more dynamic warm-up. All remaining testing followed the same order for all participants to keep the process and order effects consistent for everyone. The testing order was 3-repetition maximum back squat, vertical jump, broad jump, drop jump, pro-agility test, grip strength assessment, push-up test, and modified Bruce protocol.

**BTrackS™ Balance Assessment**

The BTrackS™ Balance Plate (Balance Tracking Systems, Inc., San Diego, CA, USA) has been found to be highly reliable and valid to measure sway and center of pressure (COP) excursion when compared to a lab-grade force plate \( r = 0.99 \) (O’Connor et al., 2016). To complete the balance assessment participants stood barefoot on the platform with feet shoulder width apart and hands on hips. The researcher read the standard BTrackS™ prompt before beginning each trial. A beep sound indicated the start and end of each trial. During each trial the participants kept their eyes closed and stood as still as possible. Participants had one practice trial followed by three - 20 s test trials. The BTrackS™ Sport Balance software provided the average COP path length and a percentile ranking based on the participant’s age and sex. Having a lower average COP path length on the BTrackS™ Sport Balance
assessment indicates less sway and better balance, which is a key aspect of flying and tumbling in cheerleading, as better balance and proprioception can improve spatial awareness and benefit many unstable functional movements (Donovan & Spencer, 2019). Both the average COP path length (cm) and percentile were recorded and included in the analysis.

**3RM Back Squat**

The three-repetition maximum back squat (3RM) is a valid \((r = 0.90)\) and reliable \((r = 0.97)\) measure of maximal strength (DiStasio, 2014; McCurdy et al., 2004). Previous research has shown that the 3RM back squat correlates with explosive movements that require lower extremity strength and power (Gabbett & Seibold, 2013). Good performance on the 3RM has been associated with increased resistance to fatigue, which would provide a benefit to collegiate cheerleaders as they must maintain high energy and effort throughout their entire routine (Gabbett & Seibold, 2013). The 3RM back squat has also been shown to have a post-activation potentiation (PAP) effect on the CMJ, improving the jump height scores (Crewther et al., 2011). Therefore, 3RM testing occurred prior to any jump testing.

A standard protocol for 3RM testing was used for this study (Moir, 2012). For the 3RM squat, participants began with a warm-up weight appropriate for them, defined as a weight known to them as a light warm-up weight or the empty 45 lb barbell if a warm-up weight is not known, for 6-8 repetitions. After resting 1 min, participants progressed to a new weight for 5-7 reps by adding 10-20 lb or 5 - 10% of the light warm-up weight. After 2 min of rest, weight increased by 10 - 20 lb or 5 - 10% and complete 4 - 6 reps. Participants were given 2-4 min of rest between this set and their 3RM attempts. Participants continued to increase their weight by 10 – 20 lb or 5 - 10% until reaching their 3RM weight. A rest period of 2 - 4 min between 3RM attempts was provided. If a participant failed to complete 3 repetitions at a weight, they were given another attempt with 5 – 10 lb (2.5 - 5%) removed. A power rack with safety bars and spotter located behind the participant were utilized throughout this test. For a repetition to count, the participant must have reached 90 degrees of knee flexion and returned to the starting standing position independently. The maximum 3RM weight was recorded as a percent of body weight and included in the analysis.
Counter Movement Jump

The countermovement jump (CMJ) is a valid \((r = 0.87)\) and reliable \((r = 0.98)\) tool for evaluating lower extremity power and explosivity (Markovic et al., 2004). The CMJ has also demonstrated significant correlations to other measures such as 1RM squats, power cleans, and dynamic strength testing (Nuzzo et al., 2008). Since there are minimal jumping or explosive skills in cheerleading that are performed with a one- or no-arm swing, participants were instructed to perform the test with a two-arm swing to make the movement more similar to the tumbling and jumping that occur in a cheerleading routine. Prior to beginning the testing trials, participants stood with both feet flat on the ground and both arms up in the air (McGuigan, 2016). The Vertec (JUMPUSA.com, Sunnyvale, CA, USA) vanes were lowered until the participant could touch only the lowest one. To perform the countermovement jump, participants were instructed to swing their arms back as they lowered their body, jump as high as possible with both arms reaching up, and displace as many vanes on the Vertec as possible (McGuigan, 2016). Each participant had one practice trial and three test trials. A minimum of 10 s of rest between trials was given. Overall maximum jump-and-reach height was recorded in centimeters and used for analysis.

Standing Broad Jump

The standing broad jump (SBJ) is a reliable \((r = 0.99)\) and valid \((r = 0.90)\) test for assessing lower extremity power (Krishnan et al., 2017; Rahman, 2021). To perform the SBJ, participants were instructed to stand with their toes on the start line, swing their arms and body to gain momentum, and jump forward as far as possible while sticking the landing. If participants took a step or fell after landing, the trial was not measured, and participants re-attempted that trial. Each participant completed one practice trial and three successful test trials. A minimum of 10 s of rest between trials was given. The distance from the start line to the heels upon landing was measured. The maximum distance was recorded in centimeters and included in the analysis.

Drop Jump

The drop jump (DJ) has been used to measure the efficiency of reactive movement and has been validated as a measure of reactive strength \((r = 0.98)\) and shown to be reliable \((r = 0.95)\) (Tenelsen et al.,
Understanding the efficiency of reactive movement is important for interpreting how athletes utilize their stretch-shortening cycle (Tenelsen et al., 2019; Ball & Zanetti, 2012). Optimizing athletes’ stretch-shortening cycle can ultimately lead to greater subsequent force production and greater tendinous and muscular elasticity, which relates to the demands of jumping and tumbling in cheerleading (Ball & Zanetti, 2012). To perform the drop jump, participants were instructed to stand on the 24” box with one foot hovering off the front edge. They were instructed to drop, not jump, off the box and jump as high as possible upon landing. At the peak of the jump, they were told to swing their arms to displace as many vanes on the Vertec as possible. Each participant had one practice trial and three test trials. A minimum of 15 seconds of rest between trials was given. The maximum jump height in centimeters was recorded and included in the analysis.

**Pro-agility test**

The pro-agility test (PAT) has been used to quantify speed and change of direction efficiency (Forster et al., 2021). The PAT has been found to be both a valid ($r = 0.90$) and reliable ($r = 0.90$) measure of speed and change of direction efficiency (Forster et al., 2021; Stewart et al., 2014). To perform the PAT, participants were instructed to straddle the start line/cone, and as quickly as they could, turn 90 degrees either direction, run five meters to touch an outer cone, turn 180 degrees, run 10 meters to touch the other outer cone, make another 180-degree turn, and run the last five meters to finish the test where they started. The time started via a stopwatch as soon as the participant began and was verified via video recordings. Each participant had one practice trial and two test trials. A rest period of one minute was given between trials. The fastest time was recorded in seconds and included in the analysis.

**Grip Strength**

Grip strength assessments are used to measure maximal strength of the upper extremity (Allen & Barnett, 2011). Dynamometers have been found to have both excellent validity ($r = 0.98$) and excellent test-retest reliability for both hands ($r = 0.98 - 0.99$) (Allen & Barnett, 2011). To perform the grip strength assessment, participants held the Grip - A Dynamometer (Takei Scientific Instruments, Tokyo, Japan) down at their sides and squeezed as hard as they could with each hand for three seconds. Each participant
had one practice trial and three trials per hand. A minimum of 10 seconds of rest between trials was
given. Investigators recorded the maximum grip strength as a percent of body weight for each hand and
included the values in the analysis.

**Push-up Test**

The push-up is an upper extremity weight-bearing exercise that uses the body weight to load the
trunk and arms (Zalleg et al., 2020). Push-ups have been correlated with increased dynamic forces, joint
stability, and power (Zalleg et al., 2020). The timed push-up test (PUT) has been found to have high
reliability \(r = 0.99\) and acceptable validity \(r = 0.58\) for testing upper extremity muscular function
(Zalleg et al., 2020; Negrete et al., 2010). To perform the PUT, participants completed three trials, each
15 seconds long with a 45 second break between trials. During the trials, participants were instructed to
do as many push-ups as possible. Each participants’ trials were video recorded to confirm the quality and
quantity of push-ups per trial. The score was calculated by averaging the number of accepted push-ups
completed across all three trials. Following the PUT, participants were given either 10 min of rest or until
their heart rate returned to their resting heart rate measure from the beginning of testing, whichever was
longer, before continuing to the Modified Bruce Treadmill protocol.

**Modified Bruce Protocol**

The modified Bruce protocol has been used to measure aerobic endurance, defined as the body’s
ability to absorb, and utilize oxygen in the muscles (Noonan & Dean, 2000). The Bruce protocol was
developed initially to diagnose heart disease but is now used for a variety of purposes including fitness
testing (Noonan & Dean, 2000). The modified version of this exercise test is more graduated and starts at
a less stressful pace than the original. The modified Bruce protocol has been found to be a valid \(r = 0.96\)
and reliable \(r = 0.98\) tool for the assessment of perfusion and usage of oxygen during exercise (Noonan
& Dean, 2000). Several equations exist to estimate \(\text{VO2}_{\text{max}}\) using total test time (Noonan & Dean, 2000).

To perform the modified Bruce Treadmill Protocol participants began on the treadmill and ended
when maximally fatigued, or they had reached the end of the protocol. There are nine stages in the
modified Bruce Treadmill Protocol with each stage lasting three minutes in duration. First, they walked
on the treadmill at 1.7 mph with no grade, then increased to a 5% grade. After this, they progressed to a 10% grade for another three minutes. Then the speed increased to 2.5 mph at a 12% grade, then 3.4 mph at a 14% grade. After that the speed increased again to 4.2 mph at 16% grade, then 5.0 mph at 18% grade, 5.5 mph at 20% grade, and finally 6 mph at a 22% grade incline. Participants only performed this test one time. Borg’s rating of perceived exertion (RPE) was recorded at each testing stage (Borg, 2006).

Investigators recorded RPE on a scale from 6, no exertion, to 20, maximal exertion (Borg, 2006). Heart rate (HR) was also recorded during each stage via a pulse oximeter, as well as a final time to exhaustion and HR recovery at one and three minutes after completing the protocol. HR recovery (HRR) was calculated as the difference between the participant’s HR immediately after ceasing the protocol and their HR after a designated amount of time resting. Once HR recovery was taken at the one- and three-minute marks, each participant did a five-minute minimum cool-down walk on the treadmill. The final time to exhaustion was used to calculate estimated VO2_max. The equation used for biological males was: VO2_max = 6.7 - 2.82 x 1 + 0.056 x T, and the equation used for biological females was: VO2_max = 6.7 - 2.82 x 2 + 0.056 x T (Ward et al., 1995).

Data Analysis

Participants were split into two groups (Anaerobic and Mixed) based on the training specificity questionnaire. To avoid unnecessary bias, the training specificity groups were not assigned until after functional testing has concluded. Two investigators independently reviewed participants’ training specificity questionnaires and assigned participants to groups. It was revealed that only two distinct groups existed – one with a majority anaerobic focus and one with an equal mix of anaerobic and aerobic focused training. Once each investigator’s assignment of groups was complete, the two investigators discussed the groupings and came to a consensus. A third investigator then independently reviewed the questionnaires and created an assignment list, which was compared to the consensus list. A final consensus list was developed, and participants were assigned to one of two groups – Anaerobic and Mixed. Out of 31 participants, 16 were categorized into the Anaerobic group and the other 15 into the Mixed (anaerobic and aerobic) group. There were no participants aligning with the aerobic focused
designation. Six of the seven male participants (86%) were assigned to the Anaerobic group, and one was assigned to the Mixed group. Ten of the 24 female participants (42%) were designated to the Anaerobic group while the other 14 were assigned to the Mixed group.

Of the sample, 18 (58%) reported having previous experience with formal strength training. Independent samples t-tests were used to identify if statistically significant differences in the data existed based on previous experience and no such differences were observed. Therefore, this factor was not included in the final analysis or separation of groups.

SPSS 27.0 was used to conduct the statistical analysis. Means and standard deviations were reported for all functional performance measures. Multiple independent samples t-tests were used to determine if significant differences existed between groups. Statistical significance was set a priori to 0.05. Cohen’s $d$ effect sizes were calculated and reported (Cohen, 1988). The scores of each participant were compared to available normative data and a percentage was determined based on how many participants reached or exceeded average.
Figure 1

Recruitment Breakdown

46 total Cheerleaders (All-Girl and Co-ed Teams)

6 Did Not Meet the Inclusion Criteria

8 Did Not Volunteer for the Study

32 Volunteered and Completed Informed Consent

1 Did Not Complete the Familiarization or Testing Sessions

31 Completed Familiarization and Testing Sessions
CHAPTER III

RESULTS

Differences in training specificity groups (Anaerobic and Mixed) were investigated and the means and standard deviations for all measures can be seen in Table 1. There was a statistically significant difference in 3RM and SBJ between groups with the Anaerobic group performing better on both tasks (3RM: Anaerobic = 135.69 ± 31.69%BW, Mixed = 116.33 ± 14.21%BW, \( p = 0.038, d = 0.84 \)); SBJ: Anaerobic = 203.36 ± 24.1cm, Mixed = 183.39 ± 15.52cm, \( p = 0.011, d = 1.01 \)). The difference in right-handed grip strength (GS-R) was not statistically significant but may be relevant based on a moderate effect size and the exploratory nature of this study (Anaerobic = 27.3 ± 4.8, Mixed 24.5 ± 4.2, \( p = 0.090, d = 0.63 \)). No other statistically significant or clinically relevant differences were observed.

Individual scores on all tests except for the drop jump were compared to available normative data or previously reported data for adult physically active individuals and/or collegiate athletes. More than 50 percent of the participants scored at or above average on all tests except for pro-agility and push-up tests. All comparisons to normative data are shown in Table 2.
Table 1

*Descriptive Statistics for Outcome Measures of Testing Battery by Training Group*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Anaerobic</th>
<th>Mixed</th>
<th>p-value</th>
<th>Effect Size (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BTracks Score, cm</td>
<td>21.88 ± 9.65</td>
<td>19.67 ± 5.51</td>
<td>0.445</td>
<td>0.15</td>
</tr>
<tr>
<td>BTracks, percentile</td>
<td>59.38 ± 32.49</td>
<td>62.13 ± 30.17</td>
<td>0.809</td>
<td>0.09</td>
</tr>
<tr>
<td>3RM, %BW</td>
<td>135.69 ± 31.69</td>
<td>116.33 ± 14.21</td>
<td>0.038*</td>
<td>0.84</td>
</tr>
<tr>
<td>CMJ, cm</td>
<td>56.6 ± 11.20</td>
<td>52.15 ± 6.10</td>
<td>0.184</td>
<td>0.51</td>
</tr>
<tr>
<td>SBJ, cm</td>
<td>203.36 ± 24.10</td>
<td>183.39 ± 15.52</td>
<td>0.011*</td>
<td>1.01</td>
</tr>
<tr>
<td>DJ, cm</td>
<td>55.33 ± 10.68</td>
<td>51.31 ± 6.10</td>
<td>0.213</td>
<td>0.48</td>
</tr>
<tr>
<td>PAT, s</td>
<td>5.58 ± 0.36</td>
<td>5.66 ± 0.28</td>
<td>0.507</td>
<td>0.24</td>
</tr>
<tr>
<td>GS L, %BW</td>
<td>56.92 ± 9.74</td>
<td>52.73 ± 8.41</td>
<td>0.211</td>
<td>0.46</td>
</tr>
<tr>
<td>GS R, %BW</td>
<td>60.18 ± 10.49</td>
<td>54.01 ± 9.28</td>
<td>0.094</td>
<td>0.62</td>
</tr>
<tr>
<td>PUT, #</td>
<td>11.31 ± 4.20</td>
<td>10.09 ± 2.95</td>
<td>0.419</td>
<td>0.34</td>
</tr>
<tr>
<td>BP T, min</td>
<td>16.64 ± 1.29</td>
<td>16.09 ± 1.28</td>
<td>0.243</td>
<td>0.55</td>
</tr>
<tr>
<td>Est. VO2, mL/kg/min</td>
<td>55.30 ± 4.42</td>
<td>58.02 ± 4.60</td>
<td>0.105</td>
<td>0.60</td>
</tr>
<tr>
<td>HRR1, bpm</td>
<td>45.19 ± 13.75</td>
<td>44.20 ± 11.52</td>
<td>0.534</td>
<td>0.08</td>
</tr>
<tr>
<td>HRR3, bpm</td>
<td>67.81 ± 11.43</td>
<td>65.87 ± 12.80</td>
<td>0.448</td>
<td>0.16</td>
</tr>
</tbody>
</table>

* p < .05
## Table 2

*Comparison of Participant Scores to Available Normative Data*

<table>
<thead>
<tr>
<th>Test</th>
<th>Average Score</th>
<th>Percentage At or Above</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
</tr>
<tr>
<td>BTracks, percentile (^a)</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>3RM, kg (^b)</td>
<td>67.5-101.6</td>
<td>42.4-56.7</td>
</tr>
<tr>
<td>CMJ, cm (^c)</td>
<td>≥40.6</td>
<td>≥30.5</td>
</tr>
<tr>
<td>SBJ, cm (^c)</td>
<td>221-230</td>
<td>171-180</td>
</tr>
<tr>
<td>PAT, s (^d)</td>
<td>4.41-4.52</td>
<td>5.01-5.17</td>
</tr>
<tr>
<td>GS, kg (^e)</td>
<td>47.0 ± 8.1</td>
<td>28.1 ± 7.1</td>
</tr>
<tr>
<td>PUT, # (^f)</td>
<td>18.88 ± 3.61</td>
<td>12.04 ± 2.79</td>
</tr>
<tr>
<td>Est. VO2, mL/kg/min (^g)</td>
<td>52.23</td>
<td>52.23</td>
</tr>
</tbody>
</table>

CHAPTER IV
DISCUSSION

The primary aim of this study was to determine if there are differences in training specificity within competitive collegiate cheerleaders that lack a formal strength and conditioning program, and to see if those differences in training specificity impact performance on common functional tests measuring balance, strength, muscular endurance, power, agility, and aerobic fitness. After interpreting the training specificity questionnaire, we identified that there were two distinct groups that differed in their training habits - an Anaerobic group and a Mixed (equal anaerobic and aerobic training) group. This supported our first hypothesis that different training groups existed among collegiate cheerleaders without a formal strength training program. Differences in performance on the 3RM and SBJ partially supported our second hypothesis of discrepancies existing between groups with different training types. Given the exploratory nature of this study, it’s important to note that relevant differences in right-handed grip strength may exist based on a moderate effect size but did not reach statistical significance. A larger sample size would need to be evaluated to confirm this observation. There was not a statistically significant difference between groups for any of the other functional tests performed, which is why our hypothesis was only partially supported. Our third hypothesis was also partially supported. The participants included in this sample reached an average score on some but not all the functional tests as compared to normative values for an age-matched physically active population.

Training Groups

In the present study, all participants lacked a formal strength and conditioning program, and there was no statistical significance in performance outcome measures when comparing the sample based on previous experience of formal strength training. Once separated by current training specificity, participants who currently focused their training on anaerobic conditioning were expected to have better scores on tests evaluating strength and power, and this matched the results observed in this study (Komi et al., 1977; Plisk, 1991). Anaerobic conditioning develops the ability to perform with bursts of strength and power (Komi et al., 1977; Plisk, 1991). Participants in this study that were assigned to the Anaerobic
group practiced exercises like squats, deadlifts, power cleans, and sprinting intervals. The Anaerobic group performed better than the Mixed group on the 3RM, SBJ, and R-GS. This was an expected result as the 3RM, SBJ, and R-GS are all tests of strength or power and correspond with the characteristics of the Anaerobic group (Allen & Barnett, 2011; DiStasio, 2014; McCurdy et al., 2004; Krishnan et al., 2017). In the current study, only half of the participants reported training in a primarily anaerobic capacity. Anaerobic training aligns closely with the demands of cheerleading and, therefore, a more focused anaerobic training program may be more optimal for this population than having an even mix of anaerobic and aerobic training.

Although some tests showed a difference between groups, not all performance outcomes were different. This may be due to multiple factors including that all participants cheer for the same university, have the same or similar practice structure, and cross-train to some degree. Though this group of participants is homogenous, as they come from the same team, they all have differing backgrounds and histories within cheerleading as well as exposure to other sports. Within this sample, there are also individuals who have been a member of the team for four years and those who have just recently joined. This offers some heterogeneity to an otherwise homogenous group of participants.

A recent study showed that endurance training alone can lead to improvements in tests that would be considered anaerobic (Gavanda et al., 2022). In that study, three training groups, high-intensity functional training, strength training, and endurance training, were assigned at random, and were given the same testing battery before and after their interventions. The battery included a 3RM, CMJ, 20-meter sprint, and the Yo-Yo test. The endurance group saw improvements in their CMJ, 20-meter sprint, and the Yo-Yo test. The strength training group saw improvements in their 3RM, CMJ, and Yo-Yo test, and finally the high intensity functional training group saw improvements in all of the tests (Gavanda et al., 2022). This study supported that more anaerobic types of training have further benefits in improving strength and explosive power (Gavanda et al., 2022).
**3-Repetition Maximum Back Squat**

Muscular strength can be defined as the maximum force a muscle or group of muscles can exert at a specific velocity (Kell et al., 2001). The back squat correlates well with cheerleading as both the base and the flyer must go through this movement pattern before throwing a stunt, additionally this movement is very similar to a cheerleader’s approach for a jump, as well as several tumbling skills. All participants in this study are expected to tumble at practices, games, events, and competition, which requires great amounts of lower extremity strength. The 3RM testing showed differences between training groups; the results were as expected, when compared to previous research, with the Anaerobic training group performing better than the Mixed group overall (Komi et al., 1977; Plisk, 1991). This test was measured as a percent of the participant’s body weight, and both groups’ means were above 100% meaning that both groups were able to squat more than their own weight on average. A recent study compared a six-week training program with testing batteries, including a 3RM, before and after the intervention (Gavanda et al., 2020). In the Gavanda et al. (2020) study, three training groups were assigned, high-intensity functional training (HIFT), strength, and endurance. The greatest post-test values for both males and females in the study by Gavanda et al., came from the strength training groups, and the lowest from the endurance training groups (2020). When comparing the values of each of our participants to the mean scores reported in their study, all but one of the female participants met or exceeded the highest post-test value for 3RM (56.7 ± 7.5) (Gavanda et al., 2020). The participant who did not reach the highest post intervention average reported for females was from the Mixed group and did exceed the lowest post intervention value (42.4 ± 7.4) (Gavanda et al., 2020). Two of the seven male participants in this study did not meet or exceed even the lowest male post-test value (67.5 ± 8.2), of those two, one was assigned Mixed and the other to the Anaerobic training group. Three of the remaining five male participants met or exceeded the highest reported post intervention value (101.6 ± 16.5), and the remaining two male participants exceeded the second highest post intervention value (71.8 ± 19.9) (Gavanda et al., 2020).

In total, 25 out of 31 (80.6%) participants in this study met or exceeded the average for the strength training or anaerobic group in the Gavanda et al. (2020) study. A previous study showed that
individuals with higher 3RM scatterplots were able to cover more distance in sprints at both slower and faster paces and were able to perform more frequent bouts of high-intensity activity, such as sprinting or jumping (Gabbett & Seibold, 2013).

**Standing Broad Jump**

The SBJ results also showed a statistically significant difference between groups, again with the Anaerobic group outperforming the Mixed group, and all but eight participants performing “above average” (Males: 221-230cm; Females: 171-180cm) for the SBJ (McGuigan, 2016). The Anaerobic group scoring better on this test is an expected result as the SBJ tests for lower extremity power, and anaerobic training is focused on building strength and power (Komi et al., 1977; Plisk, 1991). Power is defined simply as “the time rate at which work is done” (Merriam-Webster, n.d.). At the beginning of a tumbling pass, cheerleaders do a skill called a “hurdle”, which mimics a broad jump in order to gain speed and momentum to be able to complete the tumbling pass. This shows that the functionality of broad jumping in cheerleading impacts their scores. Since all cheerleaders are expected to tumble, this is an action that cheerleaders are familiar with and may be inherently better at than other tests, due of the number of repetitions they perform on a day-to-day basis in practice.

**Grip Strength Assessment**

While there were no statistically significant results for L-GS or R-GS, the difference between groups for R-GS had a p-value under 0.1 and a moderate effect size of $d = 0.62$. Given the exploratory nature of this study, it may have functional relevance and be a comparison worth exploring further in future studies. In a similar study with a larger population, researchers may see statistically significant results from grip strength assessments between anaerobic and mixed training groups. It is reasonable to assume that dominance may be a contributing factor in these results. Five of the seven male participants met or exceeded average normative scores (47.0 ± 8.1) and 20 out of the 24 female participants met or exceeded the average normative score (28.1 ± 7.1) (Wang et al., 2018). Overall, 80% of the participants in this study scored at or above average for the grip strength assessment (Wang et al., 2018). Grip strength heavily correlates with stunting and tumbling within cheerleading. Bases must have significant grip
strength to hold the foot of the flyer without losing balance. Additionally, flyers occasionally do stunts called “hand-in-hands” where the flyer is doing a handstand on the base’s hands. In this case, both the flyer and the base must use grip strength to keep the stunt in the air. While grip strength may not seem directly correlated to tumbling, it takes an immense amount of forearm and hand strength to tumble on one’s hands. The quantity of force required to complete a tumbling sequence is significant and upper body strength, including forearm and hand strength, is crucial to ensure the safety and completion of the movement and the routine in its entirety.

*BTrackSTM Sport Balance Assessment*

Balance is defined as the ability to maintain an upright position in the presence of small kinematic perturbations or disturbances (O’Connor et al., 2016). This requires control of postural sway over the body’s base of support by manipulating the position of the center of mass (O’Connor et al., 2016; Goble et al., 2019). Balance and how it relates to cheerleading, by stunting position, has been assessed previously, however, the current study’s parameters do not differentiate between position groups (Johnson, 2020). The results of the current study did not show a significant difference between the Anaerobic and Mixed groups for the BTracks Balance Assessment outcomes. The mean percentile score by group varied from 59% to 62% with an average of 60.7%. This shows that while they consistently performed above the average (50%), when compared to age-matched physically active populations, there was not a significant difference between groups on this test (Goble et al., 2019). This is not a surprising result as all cheerleaders are expected to tumble, and both flyers and bases need good balance to maintain a stunt.

*Counter-Movement Jump*

The results of the CMJ showed no statistically significant difference between groups in this study. While this test may be used as a lower extremity power test, the Anaerobic group did not perform better than the Mixed group. This is likely due to the fact that all cheerleaders are required to jump, and the amount of time they spend in practice is greater than the amount of time they reported spending training outside of practice. Jumping is required in nearly every aspect of cheerleading. Both bases and flyers need
to use explosive force to enter a stunt, tumbling requires a lot of power to perform safely, and there are individual jumping sections in the routines as well. The group means ranged from “above average” to “very good” when compared to normative values with every single participant performing at least above average (Males: ≥40.6cm; Females: ≥30.5cm) (McGuigan, 2016). This indicates that, while there may not be a significant difference between groups, the participants performed better than an age-matched physically active population.

**Drop Jump**

There were no statistically significant results for the DJ test. When the results from the DJ were compared to the CMJ no significant differences were observed. Most participants scored the same or within 2.5cm of their CMJ when performing the DJ. The largest variance found between tests was ±7.6cm. The lack of significant decline compared to their CMJ suggests that all participants demonstrated the ability to efficiently absorb force upon landing and quickly switch to producing enough power to complete the subsequent vertical jump at a similar height as the CMJ alone. A previous study showed that having an overhead target for this movement, as the participants in this study did, can increase jump height by nearly 6%, while another study suggested that the DJ is one of the best activities to implement to improve plyometric capabilities (Mok et al., 2017; Stojanović et al., 2017). It is logical to conclude that flyers may have an increased chance of scoring well on this test as they frequently perform a similar movement, however, participants in this study were compared based on position. The DJ can be likened to dismounting one stunt to then jump directly into the next stunt. This movement can also be compared to a tumbling sequence as cheerleaders typically do multiple skills in succession in a tumbling pass. The DJ findings can again be attributed to the functionality of the movement in cheerleading and the frequency with which the participants perform this movement in practice compared to their workouts.

**Pro-Agility Test**

The PAT is a test of agility, which has been defined as “a rapid, whole-body movement with change of velocity or direction in response to a stimulus” (Sheppard & Young, 2006). While it may seem like this test may correlate well with cheerleading, not a single participant scored “above average” and
most of them were below the average score (Male: 4.41-4.52s; Female: 5.01-5.17s) for an age-matched physically active population (Hoffman, 2006). Additionally, there were no statistically significant findings for the PAT between groups. Throughout their routines the cheerleaders travel all over the mat, however, this is not typically done at top speed and/or with sharp changes in direction, such as the two 180-degree changes in direction required in this test. Therefore, the PAT can be seen as an area of weakness for this group of participants. It is known that rapid change of direction is linked to non-contact anterior cruciate ligament (ACL) tears and thus underperforming on this test may be an indicator of increased likelihood of injury (Boden et al., 2000; Fox, 2018). If this weakness was targeted with adequate formal strength and conditioning, cheerleading teams may reduce the risk of non-contact ACL injuries on the mat. However, the functionality of this test may translate better to the demands of sports like basketball or American football (Forster et al., 2022; Hoffman, 2006; McGuigan, 2016).

**Push-Up Test**

The results of this test were not statistically significant between groups. When comparing the performance of each participant to normative averages, only five participants achieved average (Males: 18.88 ± 3.61; Females: 12.04 ± 2.79) or above scores on this test (Negrete et al., 2010). The PUT correlates well with the demands of cheerleading, specifically for the demands placed on bases. Bases are required to hold multiple stunts throughout the routine for many seconds at a time, sometimes back-to-back. Additionally, they are expected to complete tumbling passes that require upper extremity strength to stabilize and propel them. Both this test and the correlated cheerleading skills require muscular endurance, which has been defined as the capacity to sustain a given level of force production over time (Strand et al., 2014). Based and how our sample performed compared to normative data, upper extremity muscular endurance appears to be an area of weakness. It would be beneficial to explore this measure further using a larger sample of collegiate cheerleaders to identify if this area of weakness is consistent across collegiate cheerleading programs who lack formal strength and conditioning resources. It has been recognized that perhaps a more applicable or functional measure of upper extremity muscular endurance
for this population could be a seated shoulder press. Future researchers should consider this change if attempting to replicate this study.

**Modified Bruce Protocol**

The Modified Bruce protocol measures aerobic capacity (VO2\text{max}), which has been described as the functional limit of the cardiovascular system (Bruce, 1984). Researchers would typically expect high estimated VO2\text{max} scores from athletes who participate in endurance-based sports like soccer and cross-country. When comparing the estimated VO2\text{max} scores of each participant to the scores reported in a study published in 2012, participants of the present study performed above average on the MBP (Hamlin et al., 2012). Hamlin et al. (2012) found that, from their 29 participants, those who were deemed to have a “high” fitness level (n=18) scored a mean VO2\text{max} of 52.23. In the current study, both the Anaerobic (55.30 ± 4.42) and Mixed groups (58.02 ± 4.60) had means above that of the 2012 study (Hamlin et al., 2012). In total, 87.1% of participants in this study performed above average (Hamlin et al., 2012). While the participants do practice for extended periods of time, their routines and the bulk of their energy expenditure occurs in 1–3-minute spans. This would suggest that above-average performance on this test for this population was a surprise. The results of the MBP support that, even though their day-to-day training is not centered around aerobic capacity, their training does have a positive effect on their aerobic capacity. It is important to point out that an estimated VO2\text{max} was calculated and used for analysis so some degree of overestimation is expected and may have inflated the comparison to normative data.

**Limitations**

There were several limitations to this study. First, participants included in this study were drawn from a convenience sample. The largest available sample of convenience would have been less than 50 participants if every single member of the cheerleading team participated in the study. Further research should include a more expansive population of collegiate cheerleaders. The second limitation was the assumption that all participants gave their maximum effort on each test. All participants were given a familiarization session before their testing session and a practice repetition before their recorded trials, but this does not negate the possibility that some participants may not have been putting forth their best effort.
or may have not been as comfortable with some of the testing procedures. Another potential limitation of the study was that participants were separated into groups by training specificity only, regardless of their stunt position. Within cheerleading, there are different positions and roles that require different areas of specialization. While all cheerleaders are expected to tumble, bases and flyers' body types may differ (Goodwin et al., 2004; Udris, 2013). Bases may need more power and strength to lift and throw flyers in the air, while flyers may require more balance and body awareness to stay in the stunt while in the air (Udris, 2013). Further research should be conducted to determine if differences in these functional tests exist between positional groups.

Although these limitations exist, the results support a difference in training, a difference between training specificity types, and a deficit in agility and upper extremity muscular endurance. This supports the statement that varied and functional training is optimal for improvements in both endurance and strength, and that formal, functional strength and conditioning programs are warranted for participants of any competitive, organized sport (Gavanda et al., 2022).

Summary

No other studies have been done that evaluate the differences in training specificity within or between collegiate cheerleading teams without formal strength and conditioning programs. Normative data does not exist for this population and should be collected in future research for the benefit of the target population. More research should be done comparing injury prevalence and frequency, functional testing scores, and performance scores during competition in cheerleading populations – collegiate and All-Star - with and without formal strength and conditioning programs. This line of research is valuable for athletic directors, athletic trainers, strength coaches, cheerleading coaches, and cheerleaders themselves as it could help those involved reduce injury rates, promote safety of the athletes, and improve performance in competition. Additionally, this research and future research could help develop an ideal training type and program for competitive collegiate cheerleaders with appropriate periodization.
CHAPTER V

CONCLUSIONS

The results of this study indicated that differences in training specificity do exist within a collegiate cheerleading program that lacks formal strength and conditioning resources. Further, differences in lower extremity strength and power may exist between collegiate cheerleaders who lack a formal strength and conditioning program based on training specificity. This is important because each sport and position has different energy needs and optimal training methods for peak performance, but collegiate cheerleading is not considered an NCAA sport, and therefore, is not required to receive the same resources. The demands of collegiate cheerleading are so great that, even without a competition at the end of the year, this population would still benefit from formal strength and conditioning considering the quantity of events they are asked to work. Collegiate cheerleading teams are asked to perform at and attend football games, men’s and women’s basketball games, volleyball games, and pep rallies. The ability to cheer at all of these events year-round, safely, requires consistent training and maintenance, if not improvement, of skills.

Even without a formal training program, more than 50% of participants in this study met or exceeded the average normative scores on balance, 3RM back squat, countermovement vertical jump, standing broad jump, grip strength, and estimated VO2\textsubscript{max} tests. However, scores on the pro-agility test and push-up test demonstrated areas of weakness in agility and upper extremity muscular endurance. The consistent below-average scores on the pro-agility test are concerning from an injury prevention perspective as rapid change of direction has been linked to non-contact ACL injury. Researchers should consider targeting this area of weakness and tracking any change in lower extremity injury prevalence.

The increased performance on the 3RM back squat and standing broad jump in the anaerobic-focused training group, along with the overall poor performance on the pro-agility and push-up tests supports the conclusion that collegiate cheerleaders should have access to formal strength and conditioning resources. Future research should continue to explore the differences between training types and positions, as well as the benefits of a structured strength and conditioning program for collegiate...
cheerleaders. Future researchers should additionally seek to establish normative data specific to competitive cheerleaders and expand this studies’ methods to cheerleading programs at schools of all sizes and levels of funding, as well as non-collegiate cheerleading teams.
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APPENDIX A

EXTENDED INTRODUCTION

Statement of the Problem

Cheerleading is associated with a high incidence of catastrophic injury, and accounts for about half of sport-related fatalities in all sports in which females participate (Boden, 2005; Mueller, 2009). A survey of 425 high school cheerleaders showed that almost 62% of the participants had suffered a cheer-related injury in their career, and nearly 17% reported five or more. In a similar study of 440 collegiate participants, 78% said they had been injured throughout their careers (Jacobson et al., 2005). The National Center for Catastrophic Sports Injury Research (NCCSIR) released 15 safety recommendations for cheerleading, most of which harp on proper mechanics, training, and supervision (Mueller, 2009). Although it has been recommended for cheerleaders to receive formal strength training, many schools do not provide these resources to their cheerleading athletes. This means that many competitive collegiate cheerleaders are participating in one of the most dangerous sports, without proper conditioning and periodization. The impact of this lack of resources on the physical fitness and functional performance of cheerleaders is currently unknown.

Aim of Research (Purpose)

To determine if there are differences in training specificity within collegiate cheerleaders that lack a formal strength and conditioning program, and to see if those differences in training specificity (aerobic, anaerobic, or combination) impact performance on common functional tests measuring balance, strength, muscular endurance, power, agility, and aerobic fitness.

Research Questions

RQ1: Do differences in training specificity exist within collegiate cheerleaders who lack a formal strength and conditioning program?

RQ2: If differences in training specificity exist, do they affect performance on common functional tests of balance, strength, muscular endurance, power, agility, and aerobic fitness?

RQ3: Do collegiate cheerleaders who lack a formal strength and conditioning program still
meet average scores on common functional tests compared to normative data for a physically active population?

**Research Hypotheses**

**H₀ (null):** Differences in training specificity do not exist among collegiate cheerleaders who lack a formal strength and conditioning program.

**H₁:** Differences in training specificity will exist within collegiate cheerleaders who lack a formal strength and conditioning program.

**H₀ (null):** Differences in training specificity do not affect performance on common functional tests.

**H₂:** Functional testing outcomes will differ between groups with different training specificity (aerobic, anaerobic, combination).

**H₀ (null):** Most collegiate cheerleaders without formal strength and conditioning will not meet average scores on common functional tests when compared to the normative data for physically active individuals.

**H₃:** Most collegiate cheerleaders who lack a formal strength and conditioning program will still meet average scores on common functional tests when compared to normative data for a physically active population.

**Independent Variables**

- Training specificity groups (3)
  - Aerobic
  - Anaerobic
  - Combination

**Dependent Variables**

- BTracks Balance System
  - Average COP path length (cm)
  - Percentile
- 3RM Back Squat
• Maximum weight (%BW)
• Countermovement Vertical Jump
  o Maximum Height (cm)
• Standing Broad Jump
  o Maximum distance (cm)
• Drop Jump
  o Maximum Height (cm)
• Pro-agility Test
  o Fastest speed (s)
• Grip Strength
  o Right maximum strength (%BW)
  o Left maximum strength (%BW)
• Push-up Test
  o Average score
• Modified Bruce
  o Estimated VO$_2$max (mL/kg/min)
  o Maximum HR (bpm)
  o Heart Rate Recovery @ 1min & 3min

**Inclusion Criteria**

1. Must be on the university’s cheer team
2. Must indicate “No” on all questions on the Physical Activity Readiness Questionnaire for Everyone (2022 PAR-Q+)
3. Must not be currently withheld from activity due to an injury
4. Must be 18-25 years of age or older

**Exclusion Criteria:**

1. Physically unable to perform the tests
2. Not 18-25 years old
3. Not a current member of the collegiate cheerleading team
4. Answers “yes” to any question on the PAR-Q+
5. Inability to complete one of the testing components.

Limitations

1. Sample size is due to the convenience sample of individuals on the cheerleading team (<50).

Assumptions

1. All participants have experience with the movements in the testing battery.
2. All participants gave maximum effort.
3. All participants were healthy.

Operational Definitions

1. Training specificity - Specific Adaptations to Imposed Demands. This is also known as the SAID principle. Training specificity refers to the concept that the more time spent developing a type of training the more physiological adaptations will occur to meet the metabolic needs of that training (Harel & Koichu, 2010).
APPENDIX B

REVIEW OF LITERATURE

History of Cheerleading

Cheerleading has been around since 1898 when the University of Minnesota organized a team of all male students to encourage their athletic teams (Lord, n.d.). Once the groups began to expand, the occasional stunt or acrobatic trick was incorporated to encourage fans to cheer more for the athletic teams, however, the cheerleaders would mostly do chants and cheers (Lord, n.d.). In the 1940s women were finally permitted to join cheerleading teams (Moritz, 2011). Since then, its evolution has gone far and beyond the initial purpose of the squad. These days, competitive cheer teams exist; these groups perform at all levels and all ages and are not solely for the entertainment of fans. Cheerleaders are highly skilled athletes who learn intricate two-and-a-half-minute routines which include stunts, tumbling, jumps, and dancing (Zdunek, 2020). Within this context, stunting is defined as a skill in which a cheerleader is supported above the performance surface by one or more people, and tumbling is defined as any “hip-over-head” skill, unassisted, that begins and ends on the performance surface (Cheer Union, 2018).

Cheerleading teams consist of two main different positions - the base and the flyer. Bases are defined as a person who is in direct contact with the performance surface and is supporting another person through a stunt (Cheer Union, 2018). A flyer is defined as the person who is being supported while above the performance surface in a stunt (Cheer Union, 2018). This new-age style of cheerleading is infinitely more physically demanding than its predecessors from the 19th century.

As cheerleading continues to grow, many governing agencies for athletics have not kept up with the demands for the sport. Cheerleading is not considered a sport by most institutions, but rather an extra-curricular activity (Cheer Union, 2018). This hinders cheerleaders' ability to grow and also protect themselves from injury in the long run. Without the sport designation, there are few mandated regulations for cheerleading globally or even nationally, and as the sport becomes more advanced it too becomes more dangerous (Mueller, 2009).
Epidemiology of Injury in Cheerleading

Studies have shown that cheerleading is associated with the highest incidence of catastrophic injury, as well as about half of sport-related fatalities in all sports where females participate (Mueller, 2009; Boden, 2005). In a study from 1982 to 2002, 29 catastrophic injuries were recorded, 27 of the injuries occurred in females (Boden et al., 2003). 17 of these were severe head injuries, 13 of which were skull fractures, and 2 of which died from the injury (Boden et al., 2003). This high incidence of serious injuries is worrisome for an athletic activity that does not have many safety requirements. Another study showed that from 1990 to 2002 injury incidence among cheerleaders increased by 110% (Shields & Smith, 2006). All of these data point to the fact that cheerleading is progressing to a place where safety parameters have not been set. In fact, the NCAA injury surveillance system does not even track cheerleading injuries since it is not an NCAA championship sport, but the issue of injuries in cheerleading is not only among collegiate cheerleaders (Boden et al., 2003).

A survey of 425 high school cheerleaders showed that almost 62% of the participants had suffered a cheer-related injury in their career, and nearly 17% reported five or more (Jacobson et al., 2004). In a similar study of 440 collegiate participants, 78% said they had been injured throughout their careers (Jacobson et al., 2005). In all populations, the most commonly injured areas were ankles, wrists, backs, and knees (Jacobson et al., 2004; Jacobson et al., 2005). Most injuries occur to the lower extremities, and the majority (52%) are sprains and strains (Boden et al., 2003). Some studies indicate that head injuries may account for up to 20% of cheerleading injuries (Mueller, 2009; Boden et al., 2003).

Studies have shown that stunts may account for 60% of cheerleading injuries and up to 96% of cheer-related concussions, while another shows that, in recent years, injury prevalence is shifting toward tumbling as more safety regulations are put in place. (Shields et al., 2009; Xu et al., 2021). Across all populations, stunting, specifically pyramids and basket tosses, is the most dangerous skill along with single-arm or single-leg stunts (Boden et al., 2003; Jacobson et al., 2005). Within stunting, bases are more likely to become injured than flyers (Shields et al., 2009). It has also been found that 86% of cheerleading injuries happen in practice rather than during competition (Shields et al., 2009).
Safety clearly factors into injury incidence within cheerleading. Setting standards and having requirements for coaches and medical coverage is paramount for the prevention of injury in cheerleading (Boden et al., 2003) (Shields & Smith, 2006) (Villarosa, 2000). Other studies have recommended strength and conditioning requirements to decrease the likelihood of injury due to the lack of cheer-specific training (Jacobson et al., 2005). The National Center for Catastrophic Sports Injury Research (NCCSIR) released 15 safety recommendations for cheerleading, most of which harp on proper mechanics, training, and supervision along with mat requirements for stunting more than 2 people high (Mueller, 2009). Other recommendations by the NCCSIR include that the NCAA make cheerleading a sport and collect data via their injury surveillance system on the epidemiology of injury in cheerleading (Mueller, 2009).

**Physical Demands of Cheerleading**

Cheerleading is a very physically demanding full-contact sport. The nature of cheerleading requires participants to be conditioned for explosive powerful moments within a nearly three-minute routine. This is a feat that necessitates incredible muscular endurance and optimal anaerobic conditioning (Donovan & Spencer, 2019). Resistance to fatigue is incredibly important in cheerleading as fatigue has been shown to decrease force production, muscular response time, and trunk stability (Donovan & Spencer, 2019). Any of these responses to fatigue may cause injury to the cheerleader or to their teammates around them. Adequate conditioning has been found to improve technique in cheerleaders (Donovan & Spencer, 2019). As the technique improves, the efficiency of movement does as well. This change decreases the energy requirement for a skill, and thus increases the time to fatigue (Donovan & Spencer, 2019). In addition to muscular endurance, cheerleaders must also train cardiovascular endurance to make it through their entire routine, sometimes without any breaks.

There is no doubt that cheerleaders place a significant load on their bodies, but mental toughness is an equally important aspect of the sport (Stroescu, 2018; Grimaud, 2013). It is crucial to be able to get back up when you fall, literally and figuratively. Having the will to attempt a skill you failed previously is the only way to improve in cheerleading (Stroescu, 2018). Cheerleaders must be trained to endure mental hardships through sport. Persevering and having a positive attitude when facing roadblocks is important
in cheerleading just as it is in any other sport. Psychological skills often used by coaches or sports psychology professionals include building self-confidence, goal setting, imagery, and arousal control (Grimaud, 2013). These skills can be implemented and trained through mental work, but also through team bonding and success and improvement in practice and the weight room.

**Biomechanics of Cheerleading**

The demand placed on cheerleading athletes varies by position and ability. Flyers require more mobility, balance, and body awareness, while bases use more explosive strength and power (Udris, 2013). Both positions are expected to tumble which requires control, full-body strength and power, coordination, and speed (Udris, 2013) (Goodwin et al., 2004). A study on 131 cheerleaders showed that males tend to have decreased mobility and flexibility when compared to female cheerleaders (Udris, 2013). Additionally, diminished scapular and hip stability were seen in both male and female participants (Udris, 2013). Overall, flyers scored better than bases on the functional movement screening (Udris, 2013).

Cheerleading can be broken down into several basic biomechanical elements. These include running, jumping, landing, and balancing (Fields et al., 2005). Both running and jumping require quick explosive force production while landing and balancing require a much more controlled contraction for shock absorption (Fields et al., 2005). Cheerleading also toes the line between anaerobic and aerobic exercise (Goodwin et al., 2004). These athletes perform powerful movements in stunting and tumbling passes nonstop for two-and-a-half minutes. The variety of skills needed by a cheerleader to perform at a high level requires proper, intentional training.

**Strength and Conditioning**

Although it may seem like strength training should be required by all elite cheer teams, many schools do not provide resources for their cheerleading athletes. This means that many competitive collegiate cheerleaders are participating in one of the most dangerous sports, without proper training. Strength and conditioning are key elements in the prevention of injuries (Jacobson et al., 2005) (Udris, 2013). Training the body to operate at maximal capacity in a controlled setting is necessary for developing spatial awareness and body control.
Cheerleading requires immense functional strength, but mobility, in most cases, cannot be sacrificed for strength (Udris, 2013). Maintaining this balance requires a strictly monitored training schedule in addition to nutrition and recovery (Stroescu, 2018; Goodwin et al., 2004). Since most collegiate cheerleading programs have only one competition each year the progression of the training must be precise to have the team peaking at an ideal time. One study used five main macrocycles to adequately prepare cheerleaders for competition (Goodwin et al., 2004). The offseason consisted of mainly rest and one week per month of intense activity (Goodwin et al., 2004). The first preseason (summer) focuses more on building strength rather than skill - athletes would strength train four times each week and do aerobic exercise twice each week (Goodwin et al., 2004). The second preseason (fall) is focused on applying the skills from the weight room to cheerleading (Goodwin et al., 2004). This is more skill training and starting to practice more frequently. Cheerleaders are also typically cheering at football games during this macrocycle. Performance season (spring) leans into conditioning for the length of the routine and scaling back on heavy lifting (Goodwin et al., 2004). Athletes should be nearly at peak performance at this point in the program. Ideally, the peak would last a month for the national competition and tryouts following that (Goodwin et al., 2004). Most cheerleaders perform at basketball games during this season as well. It is clear that high school and collegiate cheerleaders require a diverse training regimen to adequately prepare themselves.

Functional Tests of Physical Performance

BTracks Sport Balance Assessment

The BTracks Balance Plate has been proven highly reliable when compared to a lab-grade force plate ($r = 0.99$), and validated as a measure of sway and center of pressure (COP) (O’Connor et al., 2016). Scoring well on the BTracks assessment indicates better overall balance which is a key aspect of flying and tumbling in cheerleading (Donovan & Spencer, 2019). Training balance and proprioception can improve spatial awareness and benefit many unstable functional movements.
**3 Repetition Maximum Squat (3RM)**

Three repetition maximum squats (3RM) are a valid \( (r = 0.90) \) and reliable \( (0.97) \) measure of maximal strength (DiStasio, 2014; McCurdy et al., 2004). The 3RM has been associated with increased resistance to fatigue and an increase in high-effort plays or movements in competition (Gabbett & Seibold, 2013). 3RM has also been shown to have a post-activation potentiation (PAP) effect on the CMJ, improving the scores (Crewther et al., 2011).

**Countermovement Vertical Jump**

The countermovement jump (CMJ) is a very common way of testing athletes at all levels. This functional test is used most frequently among football and track and field athletes. The CMJ is a valid and reliable tool for evaluating lower extremity power and explosiveness (Markovic et al., 2004). In fact, data has shown that there is a significant correlation for validity of \( r = 0.87 \) between CMJ explosive power and it has been deemed reliable \( (0.98) \) (Markovic et al., 2004). The CMJ has also demonstrated significant correlations to other measures such as 1RM squats, power cleans, and dynamic strength testing (Nuzzo et al., 2008).

**Drop Jump**

The drop jump (DJ) is used to measure the efficiency of reactive movement, this test has been validated and proven to be reliable (Tenelsen et al., 2019). Understanding the efficiency of reactive movement is important for interpreting how athletes utilize their stretch-shortening cycle (SSC) (Tenelsen et al., 2019; Ball & Zanetti, 2012). Optimizing athletes’ SSC can ultimately lead to greater subsequent force production and greater tendinous and muscular elasticity (Ball & Zanetti, 2012). The DJ has been validated as a measure of reactive strength \( (r = 0.98) \), and proven reliable \( (r = 0.95) \) (Tenelsen et al., 2019). Use of an electronic mat and force plate have also been validated and proven reliable for the DJ (Tenelsen et al., 2019).

**Standing Broad Jump**

The standing broad jump (SBJ) is another functional test that is used frequently by all levels of sport. The SBJ is also reliable and valid for assessing lower extremity power (Krishnan et al., 2017). This
test has been shown to have positive correlations in weightlifting and wrestling, two sports that require immense lower extremity strength and power (Krishnan et al., 2017). Studies have shown that the SBJ is a reliable test (0.99) as well as having excellent construct validity (0.90) in the assessment of leg power (Rahman, 2021).

**Pro Agility Test**

The pro-agility test is used to quantify speed and change of direction (COD) efficiency (Forster et al., 2021). Understanding how acceleration and deceleration differ in muscle action is crucial to identifying potential biomechanical issues in athletes. Research has shown that some athletes can even compensate for poor COD speed with above-average straight-away speed (Forster et al., 2021). The pro-agility test has been proven both a valid (0.90) and reliable (0.90) measure of speed and COD (Forster et al., 2021; Stewart et al., 2014).

**Grip Strength**

Grip strength assessments are used to measure maximal strength of the upper extremity (Allen & Barnett, 2011). This tool can also be used as a measure of progress for hand, wrist, or forearm injuries. Electronic dynamometers have been proven to have both excellent validity (0.98) and excellent test-retest reliability for both hands (0.98 & 0.99) (Allen & Barnett, 2011).

**Push-up Test**

The push-up is an upper extremity weight-bearing exercise that uses the body weight to load the trunk and arms (Zalleg et al., 2020). Push-ups have been correlated with increased dynamic forces, joint stability, and power (Zalleg et al., 2020). The timed push-up test has been proven to be a highly reliable (0.99) and valid (0.58) test for upper extremity muscular function (Zalleg et al., 2020; Negrete et al., 2010).

**Modified Bruce Protocol**

The modified Bruce protocol is used to measure aerobic endurance, this is defined by the body’s ability to absorb and utilize oxygen in the muscles (Noonan & Dean, 2000). The Bruce protocol was developed initially to diagnose heart disease but is now used for a variety of purposes including fitness
testing (Noonan & Dean, 2000). The modified version of this exercise test is more graduated and starts at a less stressful pace than the original. There are 9 stages in the modified bruce protocol, but participants are not required to finish the entire test. Borg’s rating of perceived exertion (RPE) will be used to monitor intensity (Borg, 2006). The RPE scale ranges from 6-20, 6 being no exertion and 20 being maximal exertion cessation of activity required (Borg, 2006). The modified Bruce protocol has been proven a valid (0.96) and reliable (0.98) tool for the assessment of perfusion and usage of oxygen during exercise (Noonan & Dean, 2000).

Summary

Though cheerleading has not been around as long as some sports, its growth in the past 20+ years is exponential. So much so that guidelines and availability of resources have not caught up with the needs of the sport. Cheerleading is highly physical and dangerous. Many teams are attempting skills at a high level without proper safety precautions, training, or medical coverage. More regulations need to be placed on cheerleading safety rules to prevent injury and make the sport safer. Governing bodies have recommended that strength and conditioning be made a part of cheerleaders’ training regimen. As the sport evolves, it becomes more and more crucial to be in elite shape when participating in competitive cheerleading. Cheerleaders also require substantial mental toughness with only one major competition per year, emotions run high for the make-or-break performance.

Collegiate cheerleaders put themselves at risk participating in one of the most dangerous sports, in addition to supporting other athletic teams from the same institution. Oftentimes the cheerleading team does not receive the recognition or resources that they deserve. Requiring medical coverage and an adequately trained coach as well as incorporating strength training into the cheer program could minimize unnecessary injuries. To make cheerleading safer, more governing bodies need to recognize cheerleading as a sport, and more research needs to be done on the epidemiology of injuries in cheer to further specify dangerous skills.
APPENDIX C

FORMS AND QUESTIONNAIRES

2022 PAR-Q+

The Physical Activity Readiness Questionnaire for Everyone

The health benefits of regular physical activity are clear: more people should engage in physical activity every day of the week. Participating in physical activity is very safe for MOST people. This questionnaire will tell you whether it is necessary for you to seek further advice from your doctor or a qualified exercise professional before becoming more physically active.

<table>
<thead>
<tr>
<th>GENERAL HEALTH QUESTIONS</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Has your doctor ever said that you have a heart condition OR high blood pressure?</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>2) Do you feel pain in your chest at rest, during your daily activities of living, OR when you do physical activity?</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>3) Do you lose balance because of dizziness OR have you lost consciousness in the last 12 months? Please answer NO if your dizziness was associated with over-breathing (including during vigorous exercise).</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>4) Have you ever been diagnosed with another chronic medical condition (other than heart disease or high blood pressure)? PLEASE LIST CONDITION(S) HERE:</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>5) Are you currently taking prescribed medications for a chronic medical condition? PLEASE LIST CONDITION(S) AND MEDICATIONS HERE:</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>6) Do you currently have (or have had within the past 12 months) a bone, joint, or soft tissue (muscle, ligament, or tendon) problem that could be made worse by becoming more physically active? Please answer NO if you had a problem in the past, but it does not limit your current ability to be physically active. PLEASE LIST CONDITION(S) HERE:</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>7) Has your doctor ever said that you should only do medically supervised physical activity?</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

If you answered NO to all of the questions above, you are cleared for physical activity.

Please sign the PARTICIPANT DECLARATION. You do not need to complete Pages 2 and 3.

Start becoming much more physically active – start slowly and build up gradually.

Follow Global Physical Activity Guidelines for your age (https://www.who.int/publications/i/item/9789240015128).

You may take part in a health and fitness appraisal.

If you are over the age of 45 yr and NOT accustomed to regular vigorous to maximal effort exercise, consult a qualified exercise professional before engaging in this intensity of exercise.

If you have any further questions, contact a qualified exercise professional.

PARTICIPANT DECLARATION

I, the undersigned, have read, understood to my full satisfaction and completed this questionnaire. I acknowledge that this physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if my condition changes. I also acknowledge that the community/fitness center may retain a copy of this form for its records. In these instances, it will maintain the confidentiality of the same, complying with applicable law.

NAME ______________________________ DATE ____________

SIGNATURE _______________________________ WITNESS _______________________________

SIGNATURE OF PARENT/GUARDIAN/CARE PROVIDER _______________________________

If you answered YES to one or more of the questions above, COMPLETE PAGES 2 AND 3.

Delay becoming more active if:

☑ You have a temporary illness such as a cold or fever; it is best to wait until you feel better.
☑ You are pregnant - talk to your health care practitioner, your physician, a qualified exercise professional, and/or complete the ePARmedix at www.ePARmedix.com before becoming physically active.
☑ Your health changes - answer the questions on Pages 2 and 3 of this document and/or talk to your doctor or a qualified exercise professional before continuing with any physical activity program.

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FOLLOW-UP QUESTIONS ABOUT YOUR MEDICAL CONDITION(S)

1. Do you have Arthritis, Osteoporosis, or Back Problems?
   If the above condition(s) is/are present, answer questions 1a-1c
   If NO go to question 2
   a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? YES NO
   b. Do you have joint problems causing pain, a recent fracture or fracture caused by osteoporosis or cancer, displaced vertebra (e.g., spondylolisthesis), and/or spondylolysis/pars defect (a crack in the bony ring on the back of the spinal column)? YES NO
   c. Have you had steroid injections or taken steroid tablets regularly for more than 3 months? YES NO

2. Do you currently have Cancer of any kind?
   If the above condition(s) is/are present, answer questions 2a-2b
   If NO go to question 3
   a. Does your cancer diagnosis include any of the following types: lung/bronchogenic, multiple myeloma (cancer of plasma cells), head, and/or neck? YES NO
   b. Are you currently receiving cancer therapy (such as chemotherapy or radiotherapy)? YES NO

3. Do you have a Heart or Cardiovascular Condition? This includes Coronary Artery Disease, Heart Failure, Diagnosed Abnormality of Heart Rhythm
   If the above condition(s) is/are present, answer questions 3a-3d
   If NO go to question 4
   a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? YES NO
   b. Do you have an irregular heart beat that requires medical management? YES NO (e.g., atrial fibrillation, premature ventricular contraction)
   c. Do you have chronic heart failure? YES NO
   d. Do you have diagnosed coronary artery (cardiovascular) disease and have not participated in regular physical activity in the last 2 months? YES NO

4. Do you currently have High Blood Pressure?
   If the above condition(s) is/are present, answer questions 4a-4b
   If NO go to question 5
   a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? YES NO
   b. Do you have a resting blood pressure equal to or greater than 160/90 mmHg with or without medication? YES NO (Answer YES if you do not know your resting blood pressure)

5. Do you have any Metabolic Conditions? This includes Type 1 Diabetes, Type 2 Diabetes, Pre-Diabetes
   If the above condition(s) is/are present, answer questions 5a-5e
   If NO go to question 6
   a. Do you often have difficulty controlling your blood sugar levels with foods, medications, or other physician-prescribed therapies? YES NO
   b. Do you often suffer from signs and symptoms of low blood sugar (hypoglycemia) following exercise and/or during activities of daily living? Signs of hypoglycemia may include shakiness, nervousness, unusual irritability, abnormal sweating, dizziness or light-headedness, mental confusion, difficulty speaking, weakness, or sleepiness. YES NO
   c. Do you have any signs or symptoms of diabetes complications such as heart or vascular disease and/or complications affecting your eyes, kidneys, OR the sensation in your toes and feet? YES NO
   d. Do you have other metabolic conditions (such as current pregnancy-related diabetes, chronic kidney disease, or liver problems)? YES NO
   e. Are you planning to engage in what for you is unusually high (or vigorous) intensity exercise in the near future? YES NO
2022 PAR-Q+

6. Do you have any Mental Health Problems or Learning Difficulties? This includes Alzheimer’s, Dementia, Depression, Anxiety Disorder, Eating Disorder, Psychotic Disorder, Intellectual Disability, Down Syndrome
   If the above condition(s) is/are present, answer questions 6a-6b  If NO go to question 7

   6a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? YES NO

   6b. Do you have Down Syndrome AND back problems affecting nerves or muscles? YES NO

7. Do you have a Respiratory Disease? This includes Chronic Obstructive Pulmonary Disease, Asthma, Pulmonary High Blood Pressure
   If the above condition(s) is/are present, answer questions 7a-7d  If NO go to question 8

   7a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer NO if you are not currently taking medications or other treatments) YES NO

   7b. Has your doctor ever said your blood oxygen level is low at rest or during exercise and/or that you require supplemental oxygen therapy? YES NO

   7c. If asthmatic, do you currently have symptoms of chest tightness, wheezing, laboured breathing, consistent cough (more than 2 days/week), or have you used your rescue medication more than twice in the last week? YES NO

   7d. Has your doctor ever said you have high blood pressure in the blood vessels of your lungs? YES NO

8. Do you have a Spinal Cord Injury? This includes Tetraplegia and Paraplegia
   If the above condition(s) is/are present, answer questions 8a-8c  If NO go to question 9

   8a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? YES NO

   8b. Do you commonly exhibit low resting blood pressure significant enough to cause dizziness, light-headedness, and/or fainting? YES NO

   8c. Has your physician indicated that you exhibit sudden bouts of high blood pressure (known as Autonomic Dysreflexia)? YES NO

9. Have you had a Stroke? This includes Transient Ischemic Attack (TIA) or Cerebrovascular Event
   If the above condition(s) is/are present, answer questions 9a-9c  If NO go to question 10

   9a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer NO if you are not currently taking medications or other treatments) YES NO

   9b. Do you have any impairment in walking or mobility? YES NO

   9c. Have you experienced a stroke or impairment in nerves or muscles in the past 6 months? YES NO

10. Do you have any other medical condition not listed above or do you have two or more medical conditions?
    If you have other medical conditions, answer questions 10a-10c  If NO read the Page 4 recommendations

    10a. Have you experienced a blackout, fainted, or lost consciousness as a result of a head injury within the last 12 months OR have you had a diagnosed concussion within the last 12 months? YES NO

    10b. Do you have a medical condition that is not listed (such as epilepsy, neurological conditions, kidney problems)? YES NO

    10c. Do you currently live with two or more medical conditions? YES NO

PLEASE LIST YOUR MEDICAL CONDITION(S) AND ANY RELATED MEDICATIONS HERE:

GO to Page 4 for recommendations about your current medical condition(s) and sign the PARTICIPANT DECLARATION.
2022 PAR-Q+

If you answered NO to all of the FOLLOW-UP questions (pgs. 2-3) about your medical condition, you are ready to become more physically active - sign the PARTICIPANT DECLARATION below:

- It is advised that you consult a qualified exercise professional to help you develop a safe and effective physical activity plan to meet your health needs.
- You are encouraged to start slowly and build up gradually - 20 to 60 minutes of low to moderate intensity exercise, 3-5 days per week including aerobic and muscle strengthening exercises.
- As you progress, you should aim to accumulate 150 minutes or more of moderate intensity physical activity per week.
- If you are over the age of 45 yr and NOT accustomed to regular vigorous to maximal effort exercise, consult a qualified exercise professional before engaging in this intensity of exercise.

If you answered YES to one or more of the follow-up questions about your medical condition:

You should seek further information before becoming more physically active or engaging in a fitness appraisal. You should complete the specially designed online screening and exercise recommendations program - the ePARmed-X+ at www.eparmedx.com and/or visit a qualified exercise professional to work through the ePARmed-X+ and for further information.

Delay becoming more active if:

- You have a temporary illness such as a cold or fever; it is best to wait until you feel better.
- You are pregnant - talk to your health care practitioner, your physician, a qualified exercise professional, and/or complete the ePARmed-X+ at www.eparmedx.com before becoming more physically active.
- Your health changes - talk to your doctor or qualified exercise professional before continuing with any physical activity program.

- You are encouraged to photocopy the PAR-Q+. You must use the entire questionnaire and NO changes are permitted.
- The authors, the PAR-Q+ Collaboration, partner organizations, and their agents assume no liability for persons who undertake physical activity and/or make use of the PAR-Q+ or ePARmed-X+. If in doubt after completing the questionnaire, consult your doctor prior to physical activity.

PARTICIPANT DECLARATION

- All persons who have completed the PAR-Q+ please read and sign the declaration below.

- If you are less than the legal age required for consent or require the assent of a care provider, your parent, guardian or care provider must also sign this form.

I, the undersigned, have read, understood to my full satisfaction and completed this questionnaire. I acknowledge that this physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if my condition changes. I also acknowledge that the community/fitness center may retain a copy of this form for records. In these instances, it will maintain the confidentiality of the same, complying with applicable law.

NAME ___________________________ DATE ___________________________

SIGNATURE ___________________________ WITNESS ___________________________

SIGNATURE OF PARENT/GUARDIAN/CARE PROVIDER ___________________________

For more information, please contact
www.eparmedx.com
Email: eparmedx@gmail.com

The PAR-Q+ was created using the evidence-based AGREE process (1) by the PAR-Q+ Collaboration chaired by Dr. Darren E. R. Warburton with Dr. Norman Gledhill, Dr. Veronica Jamnik, and Dr. Donald C. McKenzie (2). Production of this document has been made possible through financial contributions from the Public Health Agency of Canada and the BC Ministry of Health Services. The views expressed herein do not necessarily represent the views of the Public Health Agency of Canada or the BC Ministry of Health Services.

Key References
Training Specificity Questionnaire

Participant ID: ________________

1. How many times per week do you exercise - not including practice?

2. What type of exercise do you do? Circle all that apply.
   a. Weightlifting
   b. Cardio (running, biking, rowing, walking, etc.)
   c. Circuit training (2-5 minute circuits)
   d. Sprint Intervals
   e. Other

3. Weightlifting
   a. How many hours per week do you lift weights?
   b. Describe the type of weightlifting exercises you perform.
   c. On a scale from 1-10 how challenging/intense are your typical weightlifting sessions?

4. Cardiovascular Training
   a. How many hours per week do you do cardiovascular training?
   b. Describe the type of cardiovascular exercises you perform.
   c. On a scale from 1-10 how challenging/intense are your typical cardio sessions?

5. Circuit Training
   a. How many hours per week do you do circuit training?
   b. Describe the type of exercises that make up your circuit training routine.
   c. On a scale from 1-10 how challenging/intense are your typical circuits?
Training Specificity Questionnaire

6. Sprint Training
   a. How many hours per week do you do sprint intervals?
   b. On a scale from 1-10 how challenging/intense are your typical sprint intervals?
      (Reference: 1 = 10% and 10 = 100% max speed sprint)

7. Other Training Types
   a. If you selected “Other” above, please describe the type of exercises you perform that don’t fit into one of the previous categories.
   b. How many hours per week do you participate in it?
   c. On a scale from 1-10 how challenging/intense are these exercises?
Participant Data Form

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<tbody>
<tr>
<td>Height:</td>
<td>Weight:</td>
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<tr>
<td>Resting HR:</td>
<td>Max HR:</td>
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BTracks

Score: ________________
Percentile: ________________

3RM

Warm-up Weight (Light) 6-8 reps: ____________
Starting Weight 5-7 reps @ 10-20lbs or 5-10% increase: ________________
Building Weight 4-6 reps: ________________
Final Weight: ________________

Vertical Jump

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Standing Broad Jump

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<tr>
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Drop Jump

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<th>Trial 3:</th>
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Pro-Agility Test

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Grip Strength (Left)

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Grip Strength (Right)

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</table>

Modified Bruce

<table>
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<th>1.7MPH / 0% Grade</th>
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</thead>
<tbody>
<tr>
<td>RPE 1:</td>
</tr>
<tr>
<td>HR 1:</td>
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</tbody>
</table>

<table>
<thead>
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<th>1.7MPH / 5% Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>RPE 2:</td>
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</table>

<table>
<thead>
<tr>
<th>2.5MPH / 12% Grade</th>
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<td>RPE 4:</td>
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<th>3.4MPH / 14% Grade</th>
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<td>RPE 5:</td>
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<tr>
<th>4.2MPH / 16% Grade</th>
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<tr>
<td>RPE 6:</td>
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</table>

Time to Exhaustion:
End HR: 1min: 3min:
To:          Rozmary, Carly
            Multcher, Jessica; Wilson, Sara

From:        Georgia Southern Institutional Review Board

Approval Date:   November 2, 2022
Expiration Date:  October 31, 2023

Subject:       Status of Application for Approval to Utilize Human Subjects in Research

Dear Rozmary, Carly

After a review of the following proposed research project, it appears that (1) the research subjects are at minimal risk, (2) appropriate safeguards are planned, and (3) the research activities involve only procedures which are allowable.

Protocol #:     H12903
Title:          Training Specificity and Functional Performance in Collegiate Cheerleaders
Maximum Number of Subjects:  50

To determine if there are differences in training specificity within collegiate cheerleaders that lack a formal strength and conditioning program, and to see if these differences in training specificity (aerobic, anaerobic, or combination) impact performance on common functional tests: measuring balance, strength, muscular endurance, power, agility, and aerobic fitness.

Purpose of Study:

Therefore, as authorized in the Federal Policy for the Protection of Human Subjects, I am pleased to notify you that the Institutional Review Board has approved your proposed research with the understanding that you will abide by the following conditions:

COVID Safety Precautions: Precautions will be taken in accordance with current Georgia Southern policies to reduce the risk of the spread of communicable diseases (including COVID-19). Researchers will monitor the current transmission risk assessment by state and county using the COVID Data Tracker provided by the CDC and increase COVID safety measures as appropriate. Follow the COVID safety guidelines of the organization whose facility they are using to conduct research, and any shared devices or equipment will be sanitized using standard sanitation methods.

Incentives: No monetary incentives are approved for this protocol.

Special Conditions:  None

If at the end of this approval period there have been no changes to the research protocol, you may request an extension of the approval period. In the interim, please provide the IRB with any information concerning any significant adverse event, whether or not it is believed to be related to the study, within five working days of the event. In addition, if a change or modification of the approved methodology becomes necessary, you must notify the IRB Coordinator prior to instituting any such changes or modifications. At that time, an amended application for IRB approval may be submitted. Upon completion of your data collection, you are required to complete a Research Study Termination form to notify the IRB Coordinator, so your file may be closed.

IRE@GeorgiaSouthern.edu

WATERS COLLEGE OF HEALTH PROFESSIONS  
DEPARTMENT OF HEALTH SCIENCES AND KINESIOLOGY

Appendix A: Informed Consent

Title: Training Specificity and Functional Performance in Collegiate Cheerleaders

We are attempting to observe your exercise performance on common functional tests assessing balance, strength, power, agility, muscular endurance, and cardiorespiratory health. The primary investigator is Carly Routman, a Graduate Assistant Athletic Trainer at Georgia Southern University. She is conducting this research in partial fulfillment of the requirement for her Master’s degree. The co-investigator and research advisor for this project is Dr. Jessica Mutchler, a faculty member at Georgia Southern University and researcher in the biomechanics lab. Dr. Sam Wilson, a biomechanist and faculty member at Georgia Southern will also be assisting with this study.

You are being asked to participate in the study, because you are a collegiate cheerleader between the ages of 18-25 years old and meet all the following criteria: no previous lower or upper extremity injury in the past 6 months, no physical limitations, no current lower or upper extremity pain, and no neurological disorders. Participation eligibility will be confirmed via The Physical Activity Readiness Questionnaire for Everyone (2022 PAR-Q+) prior to starting data collection. Once eligibility is confirmed and the informed consent is signed, your resting heart rate will be measured, and you’ll complete a questionnaire to describe your training specificity. You will then complete a dynamic warm-up, like how you would warm up for practice.

Following the warm-up, testing will begin with a balance test on a platform low to the ground that will record your movement. Next, a 3RM squat protocol will be followed to determine your 3RM for back squat. Following the 3RM test, you will complete three jumping tests: 1) the countermovement jump, where you’ll jump as high as possible for three maximal attempts, 2) the broad jump, where you’ll jump as far as possible for three maximal attempts, and 3) the drop jump, where you’ll step off a 24” box and immediate jump up as high as possible across three maximal attempts. The next test will be the pro-agility drill, also known as the 20-yard shuttle drill. You will complete the trial as quickly as possible and will have two test trials. Following the pro-agility drill your maximum grip strength will be measured for both hands. After this you will perform the push-up test. You’ll be asked to perform as many push-ups as possible in 15 seconds with three test trials. The push-up test will be video recorded for use in scoring, but this video will be deleted immediately upon scoring and before you leave the session. All tests will have a familiarization trial and you will be given adequate rest between trials and tests. Lastly, you’ll complete the Modified Bruce Protocol approximately 10 minutes after your push-up test to provide rest between the anaerobic and aerobic components of the testing. The Modified Bruce protocol is a treadmill exercise test that follows a specific progression through a maximum of 9 stages with 3 minutes each stage. Each stage involves an increase in treadmill speed and/or incline. Your heart rate and rate of perceived exertion (RPE) will be recorded throughout the test, and you are allowed to stop the test when desired. Following the exercise testing, you’ll complete a cool down of walking and stretching. All testing will occur in one session that will take
approximately one hour and 30 minutes.

The associated risks with participation in this study are no greater than risk associated with routine physical activity ranging from low to high intensity. These risks include muscle soreness and risk of tripping while running. You understand that medical care is available in the event of injury resulting from this research. Should medical care be required, you may contact your primary care physician, or if you are a student who has paid your Health Fee, you may schedule an appointment at Georgia Southern University Student Health Services via your Online Student Health Portal. By signing this consent form, you confirm that Georgia Southern is not financially responsible for any incurred injury expenses.

Precautions will be taken in accordance with current Georgia Southern policies to reduce the risk of the spread of communicable diseases (including COVID-19). You have the right to request specific Covid-19 safety measures and we will accommodate as many as possible. We will tell you before you begin participation in any measures we cannot accommodate. Consenting to participate in this research indicates your acknowledgement of the risk of disease transmission. You also acknowledge your requirement to notify the researchers in the event that you test positive for COVID within 5 days prior, are symptomatic prior to or at the time of participation or receive a positive COVID test within 5 days after participation.

You understand there are no direct benefits to participating in this study. However, we can provide you with your results upon request once the study is completed. Your participation will allow the investigators to provide research support that may be of benefit to coaches, athletes, athletic administrators, strength and conditioning specialists, etc.

All information gathered within this study will be kept confidential. Data will be de-identified using a participant code. De-identified data will be stored on a password protected computer in my custody throughout the duration of this study and reported as group information in the final report. De-identified or coded data from this study may be placed in a publicly available repository for study validation and further research. You will not be identified by name in the data set or any reports using information obtained from this study, and your confidentiality as a participant in this study will remain secure. Subsequent uses of records and data will be subject to standard data use policies which protect the anonymity of individuals and institutions. Dr. Mutchnik will be the only person with access to initial forms linking your name with your participant ID. These forms will be kept in a locked file cabinet in a locked office, within a secure building. There is one exception to confidentiality that we need to make you aware of. In certain research studies, it is our ethical responsibility to report situations of child or elder abuse, child or elder neglect, or any life-threatening situation to appropriate authorities. However, we are not seeking this type of information in our study, nor will you be asked questions about these issues.

There is no use of deception in this study. You have the right to ask questions and have those questions answered. If you have questions about this study, please contact Carly Routman or Dr. Mutchnik, whose contact information is located at the end of the informed consent. For questions concerning your rights as a research participant, contact Georgia Southern University Institutional Review Board at 912-478-5465 or irb@georgiasouthern.edu. You understand you do not have to participate in this project and your decision to participate is purely voluntary. If at any time you choose to end your participation in this study, you may do so by telling the primary investigator, Carly Routman, with no penalty or loss of benefit to which you are otherwise entitled. Owing to the scientific nature of the study, the primary investigator reserves the right to terminate the procedures and/or investigation at any time. Any data already collected prior to your withdraw will be removed and/or properly destroyed and disposed of.

You must be 18 years of age or older to consent to participate in this research study. If you consent to participate in this research study and the terms above, please sign your name and indicate the date below.

You will be given a copy of this consent form to keep for your records. This project has been reviewed and approved by the GS Institutional Review Board under tracking number [123456].
Title of Project: Training Specificity and Functional Performance in Collegiate Cheerleaders

Principal Investigator: Carly Routman, LAT, ATC, (561) 685-5353, cr21763@georgiasouthern.edu

Co-Investigator and Research Advisor: Jessica Mutchler, PhD, LAT, ATC, (757) 818-0451, jmutchler@georgiasouthern.edu

Co-Investigator: Sam Wilson, PhD, (662) 560-3115, sjwilson@georgiasouthern.edu

If you consent to participate in this research study and to the terms above, please sign your name and indicate the date below:

______________________________  ____________________
Participant Signature         Date