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The Impact of Flexibility on Balance in Rifle Athletes

Ileia Nagelkirk

The University of Akron
Abstract

Research has shown that there may be a connection between flexibility and balance when evaluating fall risk in older adults and flexibility’s effect on a balance test (Emilio, Hita-Contreras, Jiménez-Lara, Latorre-Román, & Martínez-Amat, 2014); Overmoyer & Reiser, (2015). Balance is an important component of many sport movements, and has been shown to be particularly important in shooting performance in both novice and Olympic rifle athletes (Mononen, Konttinen, Viitasalo, Era, 2007; Ball, Best, Wrigley, 2003). The purpose of this study was to find if there was a relationship between a rifle athlete’s flexibility and their balance ability, to determine if flexibility training would be beneficial to incorporate into their training program. Sixteen participants (nine females, seven males) went through two trials of ten different range of motion measurement. Between range of motion trials the participants conducted the Postural Stability Test on the Biodex Stability System (BBS, Biodex, Inc., Shirley, New York) to determine their overall stability index, a measure of their balance. The range of motion values were compared to the overall stability index. No significant correlations were found when evaluating all the participants. The male participants alone showed a stronger correlation than females when evaluating the maximum and minimum measurements of flexibility together. The lack of strong correlations between flexibility measurements and balance would require further research to determine if there is a stronger relationship between flexibility and balance.
The Impact of Flexibility on Balance in Rifle Athletes

Flexibility can be defined in multiple ways. There are two different types of flexibility according to the Gleim, & McHugh, (1997) static and dynamic flexibility, or stiffness. Static flexibility has been defined as the range of motion that is possible to a joint or series of joints which can be measured using different flexibility tests including the sit and reach test (Gleim et al., 1997). Dynamic or active stiffness is referred to “the ability to transiently deform contracted muscle” (Gleim et al., 1997, pg. 290), measured using a damped oscillation technique. Static stretching training programs are linked to improving chronic flexibility, along with strength training. Flexibility training with injury prevention has been controversial throughout research studies and results can vary depending on the sport of the athlete. Generally, flexibility training is assumed to prevent muscle strain injuries, due to a more compliant muscle. The effect of flexibility training varies due to differences in the muscle fiber types in the individuals, and the activities that they participate in. Flexibility training needs to be different and customized depending on the sport of the athlete, and the movements that it requires. The viscoelastic and mechanical properties of the tissues can also affect the range of motion (ROM) that a joint can offer. Measurements of static flexibility does not show the effect of mechanic properties of the muscles, but measurements of dynamic flexibility may show the effect changes in mechanic properties may have after a muscle strain. It has been shown that flexibility can have a positive or negative effect, based on the type of activity and the type of athlete, leading to further research needed to know whether flexibility training would be beneficial for a specific activity or athlete, such as a rifle athlete (Gleim et al., 1997).

Balance is defined as an individual’s ability to maintain their center or mass, or “line of gravity within their base of support (Balance, 2019). Balance can be separated into static and
dynamic balance. Static balance is the “ability to maintain the body in some fixed posture”, or in a fixed position (Balance, 2019). Dynamic balance can be defined as “the ability to maintain postural stability and orientation with the centre of mass over the base of support while the body parts are in motion” (Balance, 2019). Through a study done by Emilio (2014), flexibility has been linked to dynamic balance. Flexibility has also been linked to scores from the Y-Balance Test which assesses balance in relation to injury risk in average or older populations by balancing on one leg, while reaching the other as far anterior, posterior to the right, and posterior to the left as the participant can reach (Overmoyer & Reiser, 2015). This still left unknown how flexibility may affect static balance for an athletic population.

In rifle athletics, static balance plays a major role in an athlete’s performance. It is shown postural or static balance, or the ability to maintain the center of mass on the base of support, is a predictor of performance or shooting accuracy in Olympic and novice rifle athletes (Ball et al., 2003; Mononen et al. 2007). Training that could improve balance, such as flexibility training may lead to increased shooting accuracy, and in turn improvement in rifle athletes performance. In a similar study evaluating flexibility on balance with archery athletes, only small correlations were found due to a small population size, not allowing a clear conclusion to be made whether flexibility is a predictor of improved balance (Ziebell, Bosak, Lowell, Phillips, Nelson, & Sanders, 2018). The purpose of this research is to evaluate and determine if there is a positive correlation between flexibility measurements and balance ability specific to rifle athletes.

**Literature Review**

Flexibility training has been researched for its benefits in a wide range of activities and populations. Research has shown that flexibility training has been able to decreases active stiffness with explosive sport movements (Gleim et al., 1997). Flexibility training has shown to
improve the speed and force of these explosive movements. With endurance activities, economy or VO\textsubscript{2} was found to be higher in individuals with lower flexibility, showing that flexibility would not be beneficial with endurance athletes (Gleim et al., 1997). The benefits flexibility training has can vary widely depending on the sport, showing to be beneficial in explosive speed movements, and possible disadvantageous for endurance activities.

Flexibility training has also been studied with its impact on balance. In older adults, a high risk of falls is shown to be linked to the flexibility and lumbar strength of the individuals (Emilio et al., 2014). Exercise programs that are aimed to improve lumbar strength and flexibility through proprioceptive exercises are shown to also improve balance, which could decrease the risk of falls in the older population. The purpose of this study was then to understand the effect a proprioceptive exercise program has on flexibility, balance, and lumbar strength, along with evaluating how these three factors are related to each other. The participants used in this study fell into a treatment group of twenty-eight participants which received a 12-week proprioceptive exercise program, and a control group of twenty-six participants which received usual care (Emilio et al., 2014). Emilio, et al., (2014) evaluated the flexibility, lumbar strength, and static and dynamic balance before and after the treatment for both groups. Flexibility was evaluated using the chair sit and reach test, along with a goniometer (Emilio et al., 2014). Dynamic Balance was evaluated using the timed get up and go test, by measuring how far the individual could walk on the balance beam in a set amount of time, timing how long the individual can balance standing still (Emilio et al., 2014). Static balance was measured using the blind flamingo test, counting the amount of trials needed to stand in a fixed position for 30 seconds (Emilio et al., 2014). The Berg Balance Test, which is a series of balance tasks that are graded on the individual’s performance, was used to assess functional balance (Emilio et al.,
Lumbar strength was measured using a digital dynamometer (Emilio et al., 2014). The risk of falls was evaluated using the Tinetti scale (Tinetti, Williams, & Mayewski, 1986). The Tinetti scale involves a gait evaluation, scoring the participants from 0-2 based on impairment on aspects of their gait, such as initiation, step length, step symmetry, trunk sway, etc. It also involves a balance evaluation, scoring the participants from 0-2 on their ability to sit, arise, their immediate standing balance, standing balance, ability to maintain balance after being nudged, with eyes closed, turning around and sitting (Emilio et al., 2014). The group that received the proprioceptive exercise class was shown to have significantly improved lumbar strength, lower body flexibility, and dynamic balance (Emilio et al., 2014). Hip-joint flexibility along with static balance were not improved. Emilio et al. (2014) also showed that flexibility, balance, and strength are all related. Fall risk was found to be associated with balance ability, but not flexibility. In conclusion, the results show that increases in lumbar strength, flexibility, and dynamic balance can decrease risk of falling in older adults, and these aspects are related to one another.

Balance and flexibility have also been shown to be related when evaluating the effect flexibility has on a balance test. Flexibility can be time consuming and hard to measure using traditional goniometer measurements due to multiple joints and multiple planes of movement per joint that would need to be measured, along with its difficulty to master. Overmoyer and Reiser (2015) wanted to determine the relationship between the Y Balance Test (Plisky, Rauh, Kaminski, Underwood, 2006), which is used to assess injury, and flexibility to show its use with determining muscle imbalances and injury risk associated with low flexibility. The Y Balance Test which consists of balancing on one leg, while reaching the other as far anterior, posterior to the right, and posterior to the left as the participant can reach, has been shown to be predictive in
showing low flexibility. The twenty participants made up of nine men and eleven women in this study completed the Y Balance Test (Overmoyer & Reiser, 2015). The researchers then measured the range of motion of nine joints for each participant through active range of motion using a goniometer. The tests were preceded by a short warm up that did not involve stretching (Overmoyer & Reiser 2015). Overmoyer & Reiser (2015) found that the scores of the Y Balance Test correlated with the active range of motion values. This showed that the test can show an increased risk for injury due to low flexibility along with showing muscle imbalances. This study also displays that balance is related to lower limb flexibility (Overmoyer & Reiser 2015). This illustrates the relationship of static flexibility measured using a goniometer to static balance of the individual measured through a balance test.

Postural stability, or static stability, along with rifle stability have shown to be a factor when evaluating shooting accuracy with rifle athletes. A study done by Mononen et al. (2007) set out to evaluate the relationship between postural balance and rifle stability with shoot score, and to see how this relationship can change from person to person. If it is shown to be related, then balance programs can be effective in improving performance for rifle athletes. For this study, fifty-eight right-handed participants that were novice rifle shooters with standard military shooting training were instructed to shoot at a stationary target (Mononen et al., 2007). Their balance was measured using a triangle shaped platform with sensors attached. Their rifle stability and shooting score were evaluated using a shooting training system called the Noptel ST 2000 sport (Noptel Inc., Oulu, Finland, www.noptel.com) (Mononen et al., 2007). The results demonstrate that there is a relationship between postural stability and rifle score when evaluating it between subject relationships, showing that stability or balance can influence the shooting accuracy of the individual (Mononen et al., 2007). This study also revealed that postural stability
can affect shooting accuracy directly through balance, or indirectly by influencing the gun stability (Mononen et al., 2007). This research indicates that balance programs can improve shooting performance when evaluating novice rifle shooters.

Balance has been evaluated with its effect on performance with Olympic rifle shooters. In a study by Ball et al., (2003), the relationship between body sway, aim point fluctuation and performance was evaluated. Six elite shooters who have competed at the Olympic level participated in the study (Ball et al., 2003). The participants were instructed to shoot twenty shots with conditions that are similar to competition. Body sway was measured using a force plate called AMTI LG6-4 (Advanced Mechanical Technologies, Inc., Massachusetts). Shooting performance and aim point fluctuation was measured using SCATT hardware and software (SCATT Shooting Performance and Analysis System, Zao, Russia). The intra-individual analysis results showed that body sway and shooting score had a negative correlation (Ball et al., 2003). As center of position movement increased, the shooting score decreased. This study found there was only a correlation between body sway and performance when evaluating the shooters at the intra-individual level (Ball et al., 2003). This study demonstrates that there is an individual association between body sway and performance. Body sway directly links to balance, indicating that there could also be a correlation between balance and performance.

Balance can be measured through a variety of systems. One system that has shown to be reproducible and reliable is the Biodex Stability System (BBS, Biodex, Inc., Shirley, New York). One study conducted by Aydog, S.T., Aydog, E., Doral M. N., & Cakci, A (2004), evaluated the reproducibility of Balance Test Scores using the Biodex Stability System (BBS, Biodex Inc., Shirley, New York) when testing blind athletes. Participants in this study included eighteen goal ball players that had total congenital blindness (Aydog et al., 2004). The participants were tested
over two days, with three trials each day using the bilateral stance of the Biodex Stability System (BBS, Biodex Inc., Shirley, New York) on the system’s most stable surface (Aydog et al., 2004). The results showed that there were no significant differences between each of the participant’s six trials, between the mean test score of each day, and the mean of the best score (Aydog, 2004). Aydog et al. (2004) conclude that the Biodex Stability System (BBS, Biodex Inc., Shirley, New York) can produce acceptable reproducibility for all the indices, more so for overall stability index and anteroposterior index. This shows the Biodex Stability System (BBS, Biodex Inc., Shirley, New York) is reliable in measuring balance in blind athletes.

Flexibility was also evaluated for its relationship to static balance in archery athletes. With the association between flexibility of balance being demonstrated through earlier studies, flexibility training with balance in archery athletes was investigated, to see if flexibility training could improve archery performance (Ziebell, et al., 2018). Eleven participants including seven males and four females conducted a submaximal aerobic test and a warm-up (Ziebell, et al., 2018). Then range of motion was evaluated using a goniometer and a series of flexibility tests including ‘sit and reach test’, ‘back scratch test’, ‘trunk extension test’. Static balance was evaluated using the athletic single leg assessment test on the Biodex Stability System (BBS, Biodex, Inc., Shirley, New York). Due to small subject size and other factors, only small correlations were found between flexibility and balance (Ziebell, et al., 2018). This study was specific to archery athletes requiring further research to evaluate flexibility’s effect on balance relating to other sports.

Flexibility training has been shown to be beneficial for different sport movements, and beneficial for improving balance in older adults (Gleim et al., 1997; Emilio et al., 2014). Flexibility has also been shown to affect balance score on different balance tests such as the Y
Balance Test (Overmoyer & Reiser 2015). Balance is shown to be a predictor in performance in different populations of rifle athletes, along with other sports that require balance, (Mononen et al., 2007; Ball et al., 2003; Ziebell, et al., 2018). The purpose of this research is to evaluate the effect of flexibility on balance in rifle athletes, using goniometer measurements to evaluate flexibility and the Biodex Balance System (BBS, Biodex Inc., Shirley, New York) to measure balance. Therefore, the research questions are would flexibility training have an effect on an athlete’s balance, and what is that effect?

**Methods**

This research was approved by The University of Akron’s Institutional Review Board (Appendix C). A total of sixteen subjects (nine females, seven males) participated in the study. All participants were from The University of Akron Rifle Team. A PAR-Q and an informed consent was completed by each participant in the study, included in Appendix A and B (Warburton, Jamnik, Bredin, & Gledhill, 2011). Each participant went through a short warm up, which included ten hip circles in each direction, ten lunges with trunk rotation, and ten leg swings to the participant’s full range of motion forward and backward on each leg. After the warm-up, range of motion measurements were conducted on all the participants using a goniometer (Prestige Medical, Model Number 64). Ten different range of motion measurements were obtained on each side of the body. These measurements included hip flexion, hip extension, hip abduction, hip adduction, hip internal rotation, hip external rotation, trunk lateral flexion, trunk extension, trunk flexion, and trunk rotation. One round of all the range of motion measurements were taken on both the right and left sides of the body.

Static balance was then determined using the Postural Stability Test on the Biodex Balance System (BBS, Biodex Inc., Shirley, New York). The participant’s age and height was
entered into the Biodex Balance System (BBS, Biodex Inc., Shirley, New York). The number corresponding to the participant was entered for the participant’s name. Participants stood on the platform in a position similar to their standing position during competitions. Each participant’s foot placement given by the Biodex Balance System (BBS, Biodex Inc., Shirley, New York) according to their height. Shoes were removed for the test. The Postural Stability Test consisted of three trials, with each trial lasting twenty seconds. Between each trial there was a ten second break where the platform stabilized. Each participant was given one practice trial before conducting the actual test to allow for familiarity of the balance test. The test had a platform stability at level 1 (most unstable) due to the participants being in healthy condition. A lower overall stability index indicates better postural control, or a better ability to maintain center or balance. The overall stability index value from the Postural Stability Test Results was used in comparison to range of motion values. Then the range of motion measurements were repeated following the balance test.

Data Analysis

The average range of motion for both right and left side of the body for type of movement were compared to the overall stability indices using Pearson’s Correlation. The average range of motion of both legs for each movement was also compared to the overall stability indices using Pearson’s Correlation. The p-value for the R values calculated from Pearson’s Correlation were calculated and recorded with a significant p-value of p ≤ 0.05.

A statistical consulting team from The University of Akron made up of Noah Hellenthal, Marie Kokora, Eric Zimmerman, and their faculty leader Dr. Richard Einsporn then analyzed the data. The maximum and minimum range of motion values of each movement were compared to the overall stability indices of all the participants. This was to account for the difference in
dominant shooting hand, assuming the grouping of each athlete’s maximum and minimum range of motion will allow for the dominant side of each athlete to be compared together. The data was further separated and analyzed according to gender, with the maximum and minimum range of motion values compared to the overall stability indices for each gender.

Lastly the data also analyzed the maximum minus the minimum range of motion values compared to the overall stability indices. First all the participants were grouped together to compare the maximum minus the minimum range of motion values with the overall stability indices, then the participants were separated by gender and analyzed. This was to determine if an imbalance in flexibility between the dominant and nondominant sides would also affect the athlete’s balance score. The range of motion measurements were taken on the same day as the balance scores.

**Results**

Very low correlation values ($≤0.47$) were found for when comparing the left, right, and both sides of the range of motion values with the overall stability index of all the participants, with all the p-values being above 0.05, showing to be statistically insignificant. These values along with their p-values were shown in Table 1. Very low correlations ($≤-0.47$) were also found when comparing the maximum and minimum range of motion values of all the participants with the overall stability indices, along with non-significant p-values. These values are shown in Table 2.

Very low correlations ($≤0.44$) were found for most of the movements except for hip flexion for the female participants. Moderate correlations were found for Hip Flexion for both the maximum (0.79) and the minimum (0.64), both with the only significant p-values ($8.21 \times 10^{-5}$, 0.004) comparing maximum and minimum range of motion values to the overall stability
indices of all the female participants. These values can be found in Table 3. The scatterplots showing the relationship between hip flexion and overall stability index in Figure 1.

Moderate correlations were found with statistically significant p-values for the correlations for the maximum and minimum hip abduction measurements (0.62) (0.64), maximum hip medial rotation measurements (-0.65), maximum and minimum hip lateral rotation measurements (0.72) (0.58), and trunk extension measurements (0.58) when evaluating the male participants, all shown in Table 4. The scatterplots showing the relationship between hip abduction, hip medial rotation, hip lateral rotation, and trunk extension with the overall stability indices are shown in Figure 2.

Very Low correlations (≤0.39) with no significant p-values were found when evaluating the maximum minus minimum range of motion values compared to the overall stability indices of all the participants, which is shown in Table 5.

A moderate correlation (-0.58) with a significant p-value (0.02) was found when evaluating maximum minus minimum values for trunk lateral flexion compared to the overall stability index for the female participants. The rest of the range of motion measurements for the female participants were shown to be low correlations (≤0.48) with no significant p-values. The scatterplot of the data is shown in Figure 3.

Moderate Correlations were found when evaluating maximum minus minimum values for male participants for trunk extension (0.58), trunk rotation (0.77), hip medial rotation (0.50), hip lateral rotation (0.61), hip flexion (0.71), and hip abduction (0.58), all with significant p-values. The scatterplot showing the data for these movements are shown in Figure 4.

Conclusion
Flexibility can have a wide range of effects, depending on the sport or athlete that is being evaluated. Previous research has shown that balance may have an effect on flexibility with different populations (Emilio et al., 2014; Overmoyer & Reiser, 2015). Since balance has been shown to be a factor in rifle shooting accuracy in performance of novice and elite athletes, researching factors that may improve balance may lead to better training programs to improve performance (Ball et al., 2003; Mononen et al., 2007). The purpose of this research was to evaluate and determine if there is a positive correlation between flexibility measurements and balance ability specific to rifle athletes.

Overall, an increase in flexibility does not seem to correlate to an increase in balance ability. When evaluating flexibility of aggregate participants, no statistical significance was found, and correlation values all were shown to be low, showing the data to be widespread and not predictive of one another. When the participants were separated by gender, the correlation values for the female participants only showed to be statistically significant for hip flexion (Table 3) and the imbalance in trunk lateral flexion (Table 6), which all showed to have a negative relationship between each other according to Figures 1 and 3. This would suggest that flexibility training may be detrimental, or may not have any effect on balance in female rifle athletes, but due to moderate to low correlations, no definite conclusions can be made. The correlations for the male participants were shown to be statistically significant for many more movements, including hip abduction, hip medial rotation, hip lateral rotation, trunk extension (Table 4), along with an imbalance in flexibility for trunk extension, trunk rotation, hip medial rotation, hip lateral rotation, hip flexion, and hip abduction (Table 7). This would suggest that flexibility training may be more beneficial in male rifle shooters, showing a positive relationship for between flexibility and balance for all the movements except the minimum value for hip
medial rotation, shown in Figures 2 and 4, but due to only moderate correlation values, no
definite conclusions can be made. Differences between males and females could be since females
tend to be more flexible than males. In conclusion, flexibility training may be beneficial in male
rifle shooters, and may be detrimental in female rifle shooters, but due to moderate to low
correlation values and wide spread data, further research would be needed to determine a
stronger relationship between flexibility and balance.

There are several limitations that could have affected the results of this study. The range
of motion measurements and the balance scores were taken according to the participant’s
schedule, rather than all the participants being tested on the same day. A participant’s range of
motion or balance score could have been affected due to the training or activities before testing.
The sample size was also small, with only sixteen participants, and was made even smaller when
the data was separated by gender, causing less data to see a correlation. The population studied
also created a restricted range, with all the participants being healthy, and having well developed
balance as all were college athletes, showing a smaller balance scores from person to person. The
general population may show more of a range of balance scores and flexibility values. Future
research could evaluate novice and collegiate athletes, to produce a wider range of flexibility
measurements and balance scores. This would also increase the sample size, allowing for more
data to determine a conclusion. Future studies incorporating a bigger population along with
eliminating other factors such as time of day, and activities participated in prior to testing could
lead to more conclusive results.
References


## Appendix A: PAR-Q

### 2019 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 help you determine whether it is necessary for you to seek further advice from your doctor or a qualified exercise professional before becoming more physically active.

### General Health Questions

Please read the 7 questions below carefully and answer each one honestly; check YES or NO.

<table>
<thead>
<tr>
<th>Question</th>
<th>YES</th>
<th>NO</th>
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<tr>
<td>1) Has your doctor ever said that you have a heart condition OR high blood pressure?</td>
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<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>
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<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>
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<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>
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<td>5) Are you currently taking prescribed medications for a chronic medical condition? Please list condition(s) and medications here:</td>
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<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 <em>does not limit your current ability</em> to be physically active. Please list condition(s) here:</td>
<td></td>
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<tr>
<td>7) Has your doctor ever said that you should only do medically supervised physical activity!</td>
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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 International Physical Activity Guidelines for your age (www.who.int/dietphysicalactivity/en/).
- 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**

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 its records. In these instances, it will maintain the confidentiality of the same, complying with applicable law.

<table>
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<tr>
<th>NAME</th>
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**SIGNATURE**

**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 ePARmed-X+ at www.parmed.com before becoming more 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.
## 2019 PAR-Q+

### 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
   - 1a. 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)
   - 1b. 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)?
   - 1c. Have you had steroid injections or taken steroid tablets regularly for more than 3 months?

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
   - 2a. Does your cancer diagnosis include any of the following types: lung/breast/ovarian, multiple myeloma (cancer of plasma cells), head, and/or neck?
   - 2b. Are you currently receiving cancer therapy (such as chemotherapy or radiotherapy)?

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
   - 3a. 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)
   - 3b. Do you have an irregular heart beat that requires medical management? (e.g., atrial fibrillation, premature ventricular contraction)
   - 3c. Do you have chronic heart failure?
   - 3d. Do you have diagnosed coronary artery (cardiovascular) disease and have not participated in regular physical activity in the last 2 months?

4. **Do you have High Blood Pressure?**
   - If the above condition(s) is/are present, answer questions 4a-4b if NO go to question 5
   - 4a. 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)
   - 4b. Do you have a resting blood pressure equal to or greater than 160/90 mmHg with or without medication? (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
   - 5a. Do you often have difficulty controlling your blood sugar levels with foods, medications, or other physician-prescribed therapies?
   - 5b. 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.
   - 5c. 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?
   - 5d. Do you have other metabolic conditions (such as current pregnancy-related diabetes, chronic kidney disease, or liver problems)?
   - 5e. Are you planning to engage in what for you is unusually high (or vigorous) intensity exercise in the near future?
### 2019 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
   - **YES** ☐ **NO** ☐

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
   - **YES** ☐ **NO** ☐

7a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? **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
   - **YES** ☐ **NO** ☐

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
   - **YES** ☐ **NO** ☐

9a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? **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
    - **YES** ☐ **NO** ☐

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.**
Appendix A: PAR-Q (continued)

2019 PAR-Q+

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 + at www.eparmed.com and/or visit a qualified exercise professional to work through the ePARmed + 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 + at www.eparmed.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 author, 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 +. 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

SIGNATURE

DATE

WITNESS

SIGNATURE OF PARENT/GUARDIAN/CARE PROVIDER

For more information, please contact

www.eparmed.com
Email: eparmed@gmail.com

The PAR-Q+ was created using the evidence-based AGREe process (1) by the PAR-Q+ Collaboration chaired by Dr. Darren J. B. Wadsworth with Dr. Norman Gledhill, Dr. Veronica Jarnik 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.

Appendix B: Informed Consent

PROTOCOL TITLE: The Impact of Flexibility on Balance in Rifle Athletes

Informed Consent Form
For Prospective Collection of Data/Information

DESCRIPTION: You are invited to participate in a research study that will compare flexibility to balance of rifle athletes. Athletes from The University of Akron Rifle Team will be tested. This research will be conducted by Ileia Nagelkirk (Principal Investigator) and Dr. Rachele Kappler in the Department of Sports Science & Wellness Education at the University of Akron. The purpose of this research is to compare the range or motion or flexibility of different lower body movements and static balance in rifle athletes, where balance is key factor in performance.

PROCEDURES: After signing the informed consent form you will undergo ten range of motion measurements. The principle investigator, Ileia, will measure your range of motion for hip flexion, hip extension, hip abduction, hip adduction, hip internal rotation, hip external rotation, trunk lateral flexion, trunk forward flexion, trunk extension, trunk rotation. Then you will follow perform the Biodex Postural Stability Balance Test on the Biodex Balance System by following the instructions on the screen. Under any circumstance you may stop the measurements or test at any time. If you do not feel comfortable under-going the measurements or test, you are not required to finish.

You are instructed to wear proper clothing during the tests, such as sweatpants or athletic shorts and a t-shirt, which will allow you to reach your full range of motion for each of the range of motion measurements. Shoes will not be worn for the balance test.

INCLUSION CRITERIA: Participant must be an athlete (as defined as a student with university athlete status or a person involved in sport specific training at least 3 times per week and compete in a sport specific competition) belonging to the Rifle Team.

EXCLUSIONS: You are not eligible to participate in this research project if you are under 18 or pregnant. You may also not participate if you have an injury that limits your range of motion.

RISKS: The range of motion measurements and Biodex Balance Test have minimal risks. Overstretching may be a risk to the range of motion measurements. Participants are instructed to only stretch until there is slight discomfort, to minimize this risk. Risk of the Balance test include loss of balance, which handlebars are provided to assist.

BENEFITS: You may benefit from this study by acquiring knowledge regarding your range of motion and balance ability.
Appendix B: Informed Consent (continued)

Each participant will be given a number, and the results of range of motion measurements along with the corresponding balance scores from the balance test will be linked to the number assigned to each participant. Names corresponding to the participant number will be recorded on a separate sheet in a separate location. The results of the data collection for this study will be used for an honors research project which will be presented as a paper and may be placed online at the university website for public access.

This study has been reviewed and approved by The University of Akron Institutional Review Board (IRB). If you have any questions about your rights as a research participant, you may call the IRB at (330) 972-7666.

This information has been explained by one or either of the following:

Ileia Nagelkirk
Dr. Rachele Kappler

I understand that they will answer any questions I may have concerning the procedures of this investigation at any time by contacting them via the information listed below. I also understand that my participation in this study is entirely voluntary, that I define myself as an athlete (as defined as a student with university athlete status or a person involved in sport specific training at least 3 times per week and compete in a sport specific competition) belonging to the rifle team, that I am not pregnant, that I must be 18 years of age or older to participate, that I have not had an injury that is currently limiting my range of motion, and that I may decline to enter this study or withdraw from it at any time without consequences. I understand that the investigators may terminate my participation in the study at any time.

Contact information about the study:
Ileia Nagelkirk (330) 671-0784 inn1@zips.uakron.edu
Dr. Rachele Kappler (330) 972-6524 kappler@uakron.edu

I understand that I am not receiving any compensation for participating in this study, other than the individual data from the testing procedures.

Signature of Research Subject ___________________________ Date ____________

Signature of Witness ___________________________ Date ____________
Appendix C: Institutional Review Board Approval Form

Date: 8/23/19
To: Ilcia Nagelkirk
   Department of Sports Science and Wellness Education
From: Katie Watkins
      Assistant VP of ORA and IRB Administrator
IRB Number: 20190803
Title: The Impact of Flexibility on Balance in Rifle Athletes

Approval Date: 8/22/19

Thank you for submitting your Request for Exemption to the IRB for review. Your protocol represents minimal risk to subjects and qualifies for exemption from the federal regulations under the category below:

☑ Exemption 2 – Research involving the use of educational tests, survey procedures, interview procedures, or observation of public behavior.

☐ Exemption 1 – Research conducted in established or commonly accepted educational settings, involving normal educational practices.

☐ Exemption 3 - Research involving the use of educational tests, survey procedures, interview procedures, or observation of public behavior not exempt under category 2, but subjects are elected or appointed public officials or candidates for public office.

☐ Exemption 4 – Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens.

☐ Exemption 5 – Research and demonstration projects conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine public programs or benefits.

☐ Exemption 6 – Taste and food quality evaluation and consumer acceptance studies.

Annual continuation applications are not required for exempt projects. If you make changes to the study's design or procedures that increase the risk to subjects or include activities that do not fall within the approved exemption category, please contact the IRB to discuss whether or not a new application must be submitted. Any such changes or modifications must be reviewed and approved by the IRB prior to implementation.

Please retain this letter for your files. This office will hold your exemption application for a period of three years from the approval date. If you wish to continue this protocol beyond this period, you will need to submit another Exemption Request. If the research is being conducted for a master's thesis or doctoral dissertation, the student must file a copy of this letter with the thesis or dissertation.

☑ Approved consent forms enclosed

The University of Akron is an Equal Education and Employment Institution
Appendix C: Institutional Review Board Approval Form (continued)

PROTOCOL TITLE: The Impact of Flexibility on Balance in Rifle Athletes

Informed Consent Form
For Prospective Collection of Data/Information

DESCRIPTION: You are invited to participate in a research study that will compare flexibility to balance of rifle athletes. Athletes from The University of Akron Rifle Team will be tested. This research will be conducted by Heia Nagelkirk (Principal Investigator) and Dr. Rachele Kappler in the Department of Sport Science & Wellness Education at the University of Akron. The purpose of this research is to compare the range or motion or flexibility of different lower body movements and static balance in rifle athletes, where balance is key factor in performance.

PROCEDURES: After signing the informed consent form you will undergo nine range of motion measurements. The principal investigator, Heia, will measure your range of motion for hip flexion, hip extension, hip abduction, hip adduction, hip internal rotation, hip external rotation, ankle plantarflexion, ankle dorsiflexion at 0°, and ankle dorsiflexion at 90°. Then you will follow perform the Biodex Balance Test on the Biodex Balance System by following the instructions on the screen. Under any circumstance you may stop the measurements or test at any time. If you do not feel comfortable under-going the measurements or test, you are not required to finish.

You are instructed to wear proper clothing during the tests, such as sweatpants or athletic shorts and a t-shirt, which will allow you to reach your full range of motion for each of the range of motion measurements.

INCLUSION CRITERIA: Participant must be an athlete (as defined as a student with university athlete status or a person involved in sport specific training at least 3 times per week and compete in a sport specific competition) belonging to the Rifle Team.

EXCLUSIONS: You are not eligible to participate in this research project if you are under 18 or pregnant. You may also not participate if you have an injury that limits your range of motion.

RISKS: The range of motion measurements and Biodex Balance Test have minimal risks. Overstretching may be a risk to the range of motion measurements. Participants are instructed to only stretch until there is slight discomfort, to minimize this risk. Risk of the Balance test include loss of balance, which handlebars are provided to assist.

BENEFITS: You may benefit from this study by acquiring knowledge regarding your range of motion and balance ability.

The University of Akron is an Equal Education and Employment Institution

Approved
Date 8/22/19

The University of Akron
Appendix C: Institutional Review Board Approval Form (continued)

Names will not be collected for this research. Each participant will be given a number, and the results of range of motion measurements along with the corresponding balance scores from the balance test will be linked to the number assigned to each participant. The results of the data collection for this study will be used for an honors research project which will be presented as a paper and may be placed online at the university website for public access.

This study has been reviewed and approved by The University of Akron Institutional Review Board (IRB). If you have any questions about your rights as a research participant, you may call the IRB at (330) 972-7666.

This information has been explained by one or either of the following:

Illea Nagelkirk
Dr. Raechle Kappler

I understand that they will answer any questions I may have concerning the procedures of this investigation at any time by contacting them via the information listed below. I also understand that my participation in this study is entirely voluntary, that I define myself as an athlete (as defined as a student with university athlete status or a person involved in sport specific training at least 3 times per week and compete in a sport specific competition) belonging to the rifle team, that I am not pregnant, that I must be 18 years of age or older to participate, that I have not have had an injury that is currently limiting my range of motion, and that I may decline to enter this study or withdraw from it at any time without consequences. I understand that the investigators may terminate my participation in the study at any time.

Contact information about the study:
Illea Nagelkirk (330) 671-0784 inl1@zips.uakron.edu
Dr. Raechle Kappler (330) 972-6524 kappler@uakron.edu

I understand that I am not receiving any compensation for participating in this study, other than the individual data from the testing procedures.

Signature of Research Subject ______________________________ Date

__________________________________________________________ Date

Signature of Witness

APPROVED

IRB

Date 8-22-17

The University of Akron
### Tables

**Correlation Between Range of Motion Measurements (Left/Right/Both) and Balance Scores**

<table>
<thead>
<tr>
<th>Movement</th>
<th>Pearson’s Correlation</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hip Flexion (Right)</td>
<td>-0.197488505</td>
<td>0.46347117</td>
</tr>
<tr>
<td>Hip Flexion (Left)</td>
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<td>Hip Extension (Right)</td>
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<td>0.287043552</td>
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<td>Hip Extension (Left)</td>
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<td>Hip Extension (Both)</td>
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<tr>
<td>Hip Abduction (Right)</td>
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<td>Trunk Lateral Flexion (Right)</td>
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<td>Trunk Rotation (Both)</td>
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</tr>
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*Table 1:* This shows Pearson’s Correlation and the P-Values comparing the range of motion values of the right, left and both sides of the body of all the participants to the overall stability indices.
## Correlation Between Range of Motion Measurements (Max/Min) and Balance Scores

<table>
<thead>
<tr>
<th>Movement</th>
<th>Pearson’s Correlation</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hip Flexion (Max)</td>
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</tr>
<tr>
<td>Hip Flexion (Min)</td>
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<td>Hip Extension (Max)</td>
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<td>Hip Abduction (Max)</td>
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*Table 2:* This shows Pearson’s Correlation and the P-Values comparing the maximum and minimum range of motion values of all the participants to the overall stability indices.
Table 3: This shows Pearson’s Correlation and the P-Values comparing the maximum and minimum range of motion values of the female participants to the overall stability indices. The blue highlighted values were found to be statistically significant.
**Figure 1:** This is a scatterplot of the data comparing the maximum and minimum range of motion values for hip flexion to the overall stability indices that were found to be statistically significant in the female participants.

**Table 4:** This shows Pearson’s Correlation and the P-Values comparing the maximum and minimum range of motion values of the male participants to the overall stability indices. The blue highlighted values were found to be statistically significant.
Figure 2: This is a scatterplot of the data comparing the maximum and minimum range of motion values to the overall stability indices that were found statistically significant in the male participants.
### Table 5: This shows Pearson’s Correlation and the P-Values comparing the maximum minus minimum range of motion measurements of all the participants to the overall stability indices.

<table>
<thead>
<tr>
<th>Movement</th>
<th>Pearson's Correlation</th>
<th>P-Value</th>
</tr>
</thead>
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<tr>
<td>Trunk Lateral Flexion (Max-Min)</td>
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<td>Hip Extension (Max-Min)</td>
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<tr>
<td>Hip Abduction (Max-Min)</td>
<td>0.184492954</td>
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### Table 6: This shows Pearson’s Correlation and the P-Values comparing the maximum minus minimum range of motion measurements of the female participants to the overall stability indices. The blue highlighted values represent the measurement that is statistically significant.

<table>
<thead>
<tr>
<th>Movement</th>
<th>Pearson's Correlation</th>
<th>P-Value</th>
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</thead>
<tbody>
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<td>Trunk Lateral Flexion (Max-Min)</td>
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<td>Trunk Extension</td>
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<td>Trunk Flexion</td>
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<td>Hip Abduction (Max-Min)</td>
<td>-0.139890316</td>
<td>0.605349</td>
</tr>
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</table>
Figure 3: This shows the scatterplot of the data comparing the maximum minus minimum range of motion to the overall stability indices for trunk lateral flexion that were found to be statistically significant in the female participants.

Table 7: This shows Pearson’s Correlation and the P-Values comparing the maximum minus minimum range of motion measurements of the male participants to the overall stability indices. The blue highlighted values represent the measurement that is statistically significant.
Figure 4: This shows the scatterplot of the data comparing the maximum minus minimum range of motion values for all movements that were found to be statistically significant in the male participants.