The Global Journal of Sport and Exercise Science (GJSES)
Vol. 2, No. 2 (2026)
ISSN (Print): 3080-0307 ISSN (Online): 3107-037X
DOI (Crossref): https://doi.org/10.63750/asah5n55

Received on: 09 February 2026 | Accepted on: 03 June 2026 | Published on: 30 June 2026

Effect of stretching protocols on strength, power, and force-velocity profile of adult amateur CrossFit practitioners

Anton Chernov [1], Koulla Parpa[2], Marcos Michaelides [3],

[1] University of Central Lancashire Cyprus, ancher450259@gmail.com
[2] University of Central Lancashire Cyprus, KParpa@uclan.ac.uk
[3] University of Central Lancashire Cyprus, MMichaelides@uclan.ac.uk

ABSTRACT

Introduction: CrossFit training commonly includes explosive and ballistic elements requiring rapid force production, therefore the type of stretching used in warm-up may alter immediate performance responses in these athletes.

Aim of the study: This study investigated the acute effects of static stretching (SS), dynamic stretching (DS), and no stretching (NS) on lower limb strength, power, jump height, and force-velocity profile in adult amateur CrossFit practitioners.

Methods: Ten well-trained male CrossFit athletes (23.5 ± 3.87 yrs) participated across three randomized and non-consecutive testing sessions. After a standardized warm-up, participants performed one of the three stretching conditions prior to maximal squat jump testing under unloaded and progressively loaded conditions using the Samozino force-velocity method. Maximal voluntary isokinetic knee extension and flexion testing was subsequently performed to evaluate peak torque and peak power. A repeated measures ANOVA was used with the level of significance set at $\rho \leq 0.05$, with Bonferroni corrected $\alpha = 0.017$.

Results: DS significantly increased squat jump height compared to NS, whereas no statistically significant differences were found between SS and DS. Stretching condition did not significantly affect relative Pmax, force-velocity imbalance, relative peak torque, or relative peak power. DS therefore provides an acute performance benefit specifically for vertical jump output, while SS did not produce reductions in performance under the short duration used.

Discussion: DS should be emphasized in CrossFit warm-ups when ballistic tasks are prioritized, while SS may still be included for mobility purposes without meaningful short-term impairment to strength or power

Keywords: warm-up strategies, ballistic performance, isokinetic strength, squat jump, neuromuscular performance.

Corresponding Author:
(Anton Chernov)
- University of Central Lancashire Cyprus.
- Email: ancher450259@gmail.com

1. INTRODUCTION

CrossFit has become one of the most rapidly growing sports over the last 10 years (Claudino et al., 2018). Once being designed to train police officers, soldiers, firefighters, and those whose work demands high level of physical fitness and readiness CrossFit quickly became extremely popular among other populations (Meyer et al., 2017). CrossFit training protocols were mainly used to optimize athletes' physical performance in ten principal domains, which are cardiovascular and respiratory endurance, strength, stamina, flexibility, speed, coordination, power, balance, agility, velocity, and accuracy (Claudino et al., 2018). Strength and power of the upper and lower body have been identified as essential factors that significantly affect performance in CrossFit practitioners, largely due to the sport's high number of ballistic movements (D'Hulst et al., 2024). Therefore, it is possible to conclude that determining factors that could boost the above-mentioned parameters would have great practical application among the CrossFit practitioners and coaches. Warm-up is known as a mandatory element of a properly structured training session that serves as an effective method of improving athlete performance (Silva et al., 2018). Stretching plays an important role as a component of warm-up and preparation of body tissues for mechanical work (Özdemir et al., 2024). Consequently, sports scientists, coaches and athletes are deeply interested in studying the effects of stretching on the physiological parameters of athletes. However, due to the wide variety of ways to perform stretching there is a need to identify the most effective one that improves performance and would be the most beneficial for exercise practitioners Daneshjoo et al. (2024). To solve the task scientists investigated the impact of different stretching protocols on the performance of ballistic movements and muscle strength among different athletic populations (Araya-Ibacache et al., 2022) (Behm et al., 2011) (Carvalho et al., 2012) (Daneshjoo et al., 2024) (Kruse et al., 2015) (Matsuo et al., 2023) (Perrier et al., 2011) (Su et al., 2017). Thus, several studies demonstrated a significant effect of performing dynamic stretching (DS) before execution of ballistic movements (countermovement and squat jumps) on power and strength comparing to static stretching (SS) or non-stretching (NS) conditions (Behm et al., 2011) (Carvalho

et al., 2012) (Daneshjoo et al., 2024) (Kruse et al., 2015) (Perrier et al., 2011) (Su et al., 2017). However, other studies either found that both SS and DS did not significantly affect ballistic performance (Araya-Ibacache et al., 2022) or did not find a significant difference between DS and SS conditions (Matsuo et al., 2023). Considering the results of the above studies, it seems possible to conclude that the choice of stretching type may significantly affect athlete's ballistic performance. Taking into consideration that CrossFit training elements are significantly related to athlete's vertical jump height, power output and maximum strength (Martínez-Gómez et al., 2020) it is possible to state that the fact that the effect of different stretching protocols on CrossFit practitioners' performance has not been discovered yet leaves a gap in the field.
Therefore, the aim of the current study is to investigate the acute effect of different stretching protocols on maximal strength, power and force-velocity imbalance among adult amateur CrossFit practitioners. Higher performance results after performing DS are hypothesized.

2. MATERIALS AND METHODS

2.1 Experimental approach to the problem

An experimental, quantitative study with a within-subjects randomized crossover repeated-measures design was conducted. Squat jump (SJ) test with the force-velocity computation method (FVP) was used to evaluate the maximum height of jumps, maximal power output ($\boldsymbol{P_{max}}$) and force-velocity imbalance ($\boldsymbol{FVP_{imb}}$) (Samozino et al., 2014). The validity and reliability of this computation method in comparison to measuring power output during maximal squat jump using force plates were scientifically confirmed (Samozino et al., 2014). The protocol of the FVP execution (Samozino et al., 2014) (vertical profiling) was chosen due to a few factors including the following: 1) the ability to run the testing procedure in a gym environment and without the use of expensive equipment, 2) simplicity of the procedure and interpretation of the results obtained; 3) accuracy of measurements.
The rationale of using SJ in the current study but not countermovement jump (CMJ) was justified by several biomechanical and methodological reasons. First of all, performing SJ gave the opportunity to isolate concentric force production. When performing CMJ stretch-shortening cycle (SSC) significantly affects the results of a jump (Hughes et al., 2022). Hence, SJ provides a research administrator with the opportunity to eliminate the influence of the SSC, thereby ensuring a more isolated measure of concentric force produced by lower limbs.

 ISSN (Print): 3080-0307 ISSN (Online): 3107-037X DOI: https://doi.org/10.63750/asah5n55

Secondly, when performing CMJ it appears to be fairly challenging for a research administrator to control the depth of the countermovement or the speed of it making sure that the conditions of the jump are the same for all the participants. If the mentioned aspects of the countermovement are not properly controlled the SSC may significantly impact the study results making it not reliable. In contrast, the SJ starts from a standardized previously recorded positions the execution of, which was strictly controlled by the research administrator for each participant, which in turn enhances reliability and reproducibility of the study. Moreover, factors mentioned above helped to minimize intra and inter – individual variability, which was essential in this particular study. Thirdly, CMJ performance significantly benefits from tendon elasticity and pre-activation of muscles, which in turn can contribute to the results of FVP disguising the true max unlike SJ (Fukutani et al., 2019).
Maximal voluntary isokinetic contraction test (MVIC) was used to identify relative peak torque and relative peak power when performing maximal concentric knee extension and flexion. The protocol of the MVIC applied was based on the protocol described in previous research assessing MVIC of the quadriceps and hamstring group muscles (Parpa & Michaelides, 2022). The measurements of MVIC were obtained by utilizing the Humac Norm and Rehabilitation system (CSMi Medical & Solution, Stoughton, MA, USA) dynamometer. The reliability and validity of the equipment utilized in strength test of the knee joint were scientifically confirmed (Habets et al., 2018).
The SS and DS protocols were implemented to the current study from the previous studies that investigated the effect of different stretching protocols on the performance of ballistic movements (Daneshjoo et al., 2024) (Araya-Ibacache et al., 2022).
The dependent variables were presented by maximal squat jump height measured in centimeters (cm), maximal power relative to body weight measured in Watts per kilograms (W/kg), FVP imbalance (**FVP_{imb}**) presented as percentage of deviation from the optimal individual force-velocity profile (**FVP_{opt}**) as well as relative peak torque measured in Newton meters per kilograms (Nm/kg), and relative peak power measured in Watts per kilograms (W/kg) obtained during maximal voluntary isokinetic contraction test (MVIC). Independent variables were presented by NS, SS and DS protocols.

2.2 Subjects

Ten healthy well trained (minimum 3 times a week for at least six months before the tests started) male CrossFit practitioners voluntarily participated in the study (age: 23.5 ± 3.87; height: 178.7 ± 5.87; weight: 77.97 ± 8.8). It is worth mentioning that the initial intention was to recruit 28 participants as the post hoc power analysis demonstrated that the sample size of 28 participants would be sufficient to detect an acceptable effect size (0.25) with $\alpha = 0.05$ and power of 0.8 (G*Power 3.1.9.7; Heinrich Heine University Düsseldorf, Germany). Indeed, most of the studies that examined the effect of different types of stretching protocols on athletes' performance used larger number of participants (Franco et al., 2008) (Kirmizigil et al., 2014) (Mahrová et al., 2014) (Matsuo et al., 2023) (Pacheco et al., 2011) (Wallmann et al., 2012). However, most of the studies were conducted in team sports such as football, basketball, volleyball or recruited teams of runners or jumpers. Due to the challenges faced when recruiting and relatively small number of CrossFit practitioners in Cyprus it was only possible to obtain 10 participants, all of whom successfully completed all the testing protocols with no dropouts. In order to be accepted for participation in the study the participants had to meet certain criteria. Firstly, each participant needed to be male CrossFit practitioner of age between 18 and 35 years who trained at least 3 times a week for the last six months prior to the testing period. Secondly, the participants should not have had any injuries to the musculoskeletal system, joint injuries or other negative ailments that would have been contraindicating factors for performing the testing procedure. Finally, before the start of the testing each participant had to provide the study administrator with filled and signed Physical Activity Readiness Questionnaire (2024 PAR-Q+) (Thomas et al., 1992) (Appendix A) along with a written consent form describing all possible consequences of the tests along with the description of the intervention (Appendix B), which was approved by the Ethical Committee of the University of Central Lancashire and was in line with the declaration of Helsinki (World Medical Association [WMA], 2008).
Exclusion criteria included less experience in CrossFit than indicated above, as well as previous surgical procedures after, which participants might not have had sufficient rehabilitation time. Additionally, athletes from sports other than CrossFit and females were also excluded from the participation in the study.

2.3 Procedures

Prior to the start of the testing the participants were familiarized with the procedure of the experiment, equipment used, protocol applied and the types of stretching used along with the participants' right to drop the study in case of private circumstances at any moment after the experiment begins. Then, 2024 PAR-Q+ (Thomas et al., 1992) was given for evaluation of the participants' health condition. As the 2024 PAR-Q+ was filled and signed the participants were asked to avoid high intense physical activities, alcohol and caffeine at least 48 hours before the tests as well as keep similar eating habits and sleeping patterns. The familiarization sessions took place at the laboratory of UCLan Cyprus and also included short demonstration of the equipment used. According to the protocol of the study all the participants were tested three times (NS, SS, and DS) on three different non-consecutive days. The testing procedures started on a different day from the familiarization session. Upon the participants' arrival on a testing day an experimental scenario for the day was blindly chosen by each participant. The order of the sessions was randomized to avoid the influence of bias and personal opinions on results of the tests. As the scenario was chosen the participants' height (in cm) was measured with Seca 206 Roller Measuring Tape (Hammer Steindamm 3-25, 22089, Hamburg Germany), body mass (in kg) was measured with Tanita BC-418 MA Body Composition Analyzer (Medical Auctions (BMA) Ltd, 15 Carfax, Horsham, West Sussex, United Kingdom), vertical distance between the dominant leg great trochanter (center of mass - CM) and the ground in a ~90°- knee angle crouch position (height of CM in starting position in cm), and lower limb length (distance between the dominant leg great trochanter to the tip toe in cm) were measured with Stanley Tylon 8m Tape Measure (Stanley Black & Decker, Inc, California, US) (Figure 1). After the measurements were done the dominant leg was determined by asking the participants, which leg would be predominantly used to kick a ball. Then each participant completed a 5-min warm-up exercise of light cycling performing 50 – 70 revolutions per minute (RPM) at an intensity of 1 kilopond at an ergometer Monark (Monark Exercise, 839 E, Sweden) to avoid any risk of injury. As the first part of warm-up was done the participants would follow the protocol according to the previously chosen scenario, i.e., would perform static (SS), dynamic (DS) stretching or would not perform any type of stretching (NS) followed by the SJ test. Prior to the SJ test the participants were again instructed in how to perform the SJ properly for the study goals and informed that the landing phase should have been performed by touching the ground keeping the same leg position as it was when taking off, i.e., extended knees with full plantar flexed feet and that the countermovement should have been excluded. During the SJ test each participant performed maximal squat jump under 5 different conditions (0% - just body weight; 40%, 60%, 80%, and 100% of body weight). For the unloaded condition (0%) the participants were holding arms crossed on the torso whereas for the additional-loads conditions a 20-kilograms weightlifting barbell and weight plates were used (Figure 2). Two attempts were performed for each condition with 20 second of rest between the attempts. At the beginning of each attempt a downward movement was performed until the previously mentioned initial crouch position with ~90°- knee angle was reached (Figure 3). As the position was taken the participants were asked to hold it for 1 second and as the command "Start" went on jump up trying to reach maximal height applying maximal force as fast as possible. After 30 seconds of rest the participants performed another attempt after, which a 2-minute rest was given before moving to the next condition. The same protocol was followed with the rest 4 conditions. For each condition the attempt when a participant managed to reach the highest vertical distance was recorded and used for further analysis.

As the SJ test was done each participant had at least 10 minutes of rest before MVIC test commenced.

Prior to the start of proceeding with measurements of MVIC each participant was put in a sitting position (initial position) with a hip joint flexed at angle of 100° and knee flexed at an angle of 105°, assuming that 0° is full extension. The chest, pelvis and the thigh of the dominant leg were held with straps to prevent distraction movements when performing the test. The lateral epicondyle of the knee joint was aligned with the joint center axis (rotation axis) of the dynamometer. After personal and anthropometric data were entered into the system each participant was encouraged to sit with arms crossed on chest and perform 3 sub-maximal repetitions of concentric knee flexion and extension for familiarization of the testing process that have been performed according to the command "One, two, three, start!". 30 seconds past the submaximal repetitions as the command "Start" went on the participants would perform 3 repetitions of maximal concentric knee extension and flexion with angular velocity of 60°/s. The participants were verbally encouraged when performing the test. The peak torque relative to participants' body weight measured in Newton-Meters per kilogram (Nm/kg) and peak power relative to participants' body weight measured in Watts per kilogram (W/kg) were recorded during the test.

The SS session consisted of four exercises meant to stretch muscles of the posterior thigh or so called "Hamstring group" including the semitendinosus, semimembranosus, and biceps femoris muscles and muscles of the anterior thigh or so called "Quadriceps" including the rectus femoris, vastus lateralis, vastus intermedius, and vastus medialis muscles. During static stretching of the hamstring group muscles the participants performed two exercises, which were presented by standing hamstring stretch and lifting leg up stretch. When performing standing hamstring stretch the participants put feet hip-width apart with fully extended knees. Then the participants leaned forward lowering upper body towards a leg trying to reach the floor with hands till the feeling of a slight discomfort. Then the same procedure would be repeated for the second leg. When performing lifting leg up stretch the participants flexed a leg in the hip joint lifting the leg up and put it on a 60 centimeters box with a fully extended knee joint. Then the participants would lean forward to the lifted leg trying to touch tip toes until they felt slight discomfort. During the static stretching of the quadriceps muscles the participants also performed two exercises, which were standing quadriceps stretches and forward lunges. When performing standing quadriceps stretches the participants stood still on one leg and performed flexion of the contralateral knee trying to maintain balance leaning against the wall with a free hand. Then, the participants would extend hip join the flexed knee stretching quadriceps as far as possible till they felt slight discomfort. At the same time, when performing forward lunges the participants tooled a forward stride keeping feet on the hip-width distance. Then the pelvis was lowered toward the floor with knee bent as low as possible (Figure 4). During all the exercises the participants reached the maximal amplitude and stayed at the position for 15 seconds isometrically. In total, 3 sets for 30 seconds each with a 20-seconds rest period between each set for each group of muscles were executed. The total time of the muscles being under stretching condition was 5 minutes.

The DS session included the same groups of muscles as the SS session, i.e., the hamstring groups and quadriceps. The DS session was performed for both the dominant and non-dominant legs as well as SS session. During the DS sessions the participants executed one exercise, which was presented by 6 subsequent sets of wide-range repetitive dynamic knee flexions and extensions keeping a straight upper body position and holding a gym stick for maintaining balance when performing. The duration of each set was 10 seconds followed by 10-second rest before starting the next set. The total time of the being under stretching condition was 1 minute.

The SJ was performed from a static half-squat position, which was represented by bending the knee joint at approximately 90-95° and tilting the torso forward at approximately 55-60° (Figure 5). The legs position was chosen to be

approximately 1.5 of biacromial breadth with feet being outwarded at approximately 45° (Figure 6). The counter movement was excluded as was stated above. The take-off phase as well as landing were performed with feet pointed downward (plantar flexion). As the participants landed the same initial crouch position was taken.
The data collected during the SJ test were carried out by utilizing the Optojump photoelectric cell system type: OPT004 (Microgate, Bolzano, Italy). The maximal jump height values demonstrated by each participant were recorded by utilizing Microgate Optojump Application MFC software (Microgate USA, New York, USA). The data collected during MVIC tests were obtained by utilizing the Humac Norm and Rehabilitation system (CSMi Medical & Solution, Stoughton, MA, USA) dynamometer. The peak torque and average power per repetition values were recorded by using HUMAC2015 Ink software (CSMi Medical & Solution, Stoughton, MA, USA). The photo materials including lower limbs position, barbell position, methods of anthropometric measurements were captured by using a photo camera of iPhone 13 (Apple Inc, Cupertino, CA, USA). Kinematic analysis of the trunk, hip, knee joints' angles kept when performing the MSJ tests was conducted by utilising Kinovea software 2023.1 version (Kinovea open-source project - www.kinovea.org). The results of jump height, $\boldsymbol{\overline{P}_{\max}}$, $\boldsymbol{FVP_{imb}}$, peak torque and relative peak power were averaged for further analysis by using Microsoft Excel software (Microsoft Corporation, Redmond, USA). The analysis of all data obtained was conducted by using IBM SPSS Statistics 26 for Windows (SPSS Inc., Chicago, USA).

2.4 Statistical analysis

The data normality distribution was analyzed by running Shapiro-Wilk test. Descriptive statistics analysis was used to identify mean and standard deviation values of the data. A repeated measures ANOVA test was used to evaluate differences of jump height (SJ), $\boldsymbol{P_{\max}}$ relative to participants body weight, $\boldsymbol{FVP_{\mathrm{imb}}}$ obtained during SJ test with use of FVP method, peak torque and peak power relative to participants body weight obtained during MVIC test. Since three pairwise comparisons were conducted to determine the difference between the conditions (NS vs. SS, NS vs. DS and SS vs. DS), the α-level was adjusted from .05 to .017 using the Bonferroni correction. Statistical analysis of the results was obtained by using IBM SPSS Statistics 26 for Windows (SPSS Inc., Chicago, USA).

3. RESULTS

Descriptive statistics analysis revealed that the mean height of SJ performed after NS condition was 18.47 cm ± 2.8 SD, the mean height of SJ performed after SS condition was 19.56 cm ± 3.02 SD, the mean height of SJ performed after DS condition was 19.97 cm ± 2.77 SD. A repeated measures ANOVA test demonstrated that the type of stretching had a significant effect of jump height $F(1.18, 10.22) = 9.95$, $p = .008$, partial $\eta^2 = .525$, after applying Greenhouse-Geisser correction due to violation of sphericity (Mauchly's $W = 0.305$, $\chi^2(2) = 9.50$, $p = .009$, $\varepsilon = .590$). The mean height of SJ performed after DS condition was significantly greater compared to the mean height of SJ performed after NS condition ($p < .05$) and slightly higher than the mean height of SJ performed after SS condition. However, no significant difference between DS and SS conditions was found ($p > .05$) (Figure 7).

Descriptive statistics analysis revealed that the mean of relative to body weight $\boldsymbol{P}_{\mathbf{max}}$ after NS was 40.92 W/kg ± 17.33 SD, the mean of relative to body weight $\boldsymbol{P}_{\mathbf{max}}$ after SS was 40.43 W/kg ± 13.5 SD, the mean of relative to body weight $\boldsymbol{P}_{\mathbf{max}}$ after DS was 37.46 W/kg ± 11.03 SD. A repeated measures ANOVA test did not indicate any significant effect of stretching condition on relative $\boldsymbol{P}_{\mathbf{max}}$ $F(2, 18) = 0.98$, $p = .395$, partial $\eta^2 = .098$ (Figure 8). Mauchly's test indicated that the assumption of sphericity was met ($W = 0.625$, $\chi^2(2) = 3.76$, $p = .153$).

Descriptive statistics analysis revealed that the mean of $\boldsymbol{FVP}_{\mathbf{imb}}$ demonstrated after NS was 39.1% ± 21.1 SD, the mean of $\boldsymbol{FVP}_{\mathbf{imb}}$ demonstrated after SS was 39 % ± 19.7 SD, the mean of $\boldsymbol{FVP}_{\mathbf{imb}}$ demonstrated after DS was 43.5 % ± 17.9 SD. A repeated measures ANOVA test did not demonstrate a significant effect of stretching conditions on $\boldsymbol{FVP}_{\mathbf{imb}}$ $F(2, 18) = 1.001$, $p = .387$, partial $\eta^2 = .1$ (Figure 9). Mauchly's test indicated that the assumption of sphericity was met ($W = 0.515$, $\chi^2(2) = 5.307$, $p = .070$).

Descriptive statistics analysis revealed that the mean of peak torque relative to participants' body weight demonstrated during MVIC test after NS was 269.87 Nm/kg ± 70.55 SD, the mean of peak torque relative to participants' body weight demonstrated during MVIC test after SS was 266.5 Nm/kg ± 76.01 SD, the mean of peak torque relative to participants' body weight demonstrated during MVIC test after DS was 267.24 Nm/kg ± 72.37 SD. A repeated measures ANOVA test did not demonstrate a significant effect of stretching conditions of relative peak torque $F(2, 18) = .152$, $p = .860$, partial $\eta^2 = .017$ (Figure 10). Mauchly's test indicated that the assumption of sphericity was met ($W = 0.619$, $\chi^2(2) = 3.832$, $p = .147$).

Descriptive statistics analysis revealed that the mean of peak power relative to participants' body weight demonstrated during MVIC test after NS was 281.7 W/kg ± 73.85 SD, the mean of peak power relative to participants' body weight demonstrated during MVIC test after SS was 279.17 W/kg ± 79.32 SD, the mean of peak power relative to participants' body weight demonstrated during MVIC test after DS was 279.56 W/kg ± 75.65 SD. A repeated measures ANOVA test did not demonstrate a significant effect of stretching conditions on relative peak power $F(2, 18) = .080$, $p = .923$, partial $\eta^2 = .009$ (Figure 11). Mauchly's test indicated that the assumption of sphericity was met ($W = 0.662$, $\chi^2(2) = 3.306$, $p = .192$).

4. DISCUSSION

The aim of the current study was to investigate the acute effect of various stretching conditions including non-stretching, static stretching and dynamic stretching on maximal strength, power and force-velocity imbalance among adult amateur CrossFit practitioners. The above-mentioned parameters were evaluated through two testing modalities, which were presented by squat jump test performed under varying load conditions and the maximal voluntary isokinetic contraction test. The study conducted aimed to provide evidence regarding the effect and role of stretching strategies as a part of warm up in optimizing athletes' performance in sports involving ballistic movements such as CrossFit. The key outcome of the study conducted is that stretching conditions had a significant effect on jump performance. Particularly dynamic stretching significantly improved jump height, whereas no significant effects of all the stretching types were observed for force-velocity imbalance, maximum power output relative to body weight demonstrated during squat jump, peak power and peak torque relative to the participants' body weight. Hence, the hypothesis was partially accepted as dynamic stretching significantly improved performance of squat jump regarding height. This finding is supported by the results of some previous studies where dynamic stretching significantly improved squat jump height (Carvalho et al., 2012) (Daneshjoo et al., 2024).

In contrast to the results obtained in the current study do not align with the results of some previous studies conducted (Araya-Ibacache et al., 2022) (Matsuo et al., 2013) where no significant effect of dynamic stretching performed on jumping performance was demonstrated.

A possible reason for the dynamic stretching effecting jump height may be the fact that dynamic stretching has consistently been associated with enhanced vertical jump performance due to its potential to increase muscle temperature, post activation potentiation (PAP), nerve conduction velocity, and motor unit recruitment (Araya-Ibacache et al., 2022) (Su et al., 2017). The results obtained in the current study support this view by showing that dynamic stretching contributed to improved squat jump outcomes compared to non-stretching and static stretching conditions.

Static stretching, in contrast, has been reported to play as a factor decreasing acute explosive strength and power, likely due to temporary reductions in muscle-tendon unit stiffness and alterations of neuromuscular function (Kay et al., 2015). However, in the current study, static stretching did not lead to significant decrements in jump height when compared to the non-stretching condition. Previous findings that demonstrated the lack of significant effect of of both static and dynamic stretching on jump height (Araya-Ibacache et al., 2022) support the outcomes of the current study regarding to static stretching but strongly contradicts to the results of dynamic stretching effect. This effect may be explained by the different protocols and duration of static stretches used, as shorter static stretching bouts (less than 60 seconds per muscle group) have been shown to produce minimal reductive effects (Behm et al., 2011).

In contrast to the significant effect observed for jump height, stretching conditions applied did not significantly impact force-velocity imbalance, relative maximum power output, peak power, or peak torque. Therefore, the findings obtained contradict to the previous findings where it was demonstrated that dynamic stretching session significantly enhanced upon peak power relative to static protocol (Kruse et al., 2015). Similarly, the findings obtained in the current study do not support some of the previously demonstrated outcome where dynamic stretching appeared to significantly increase the participants' power and strength Daneshjoo et al., 2024) (Matsuo et al., 2013) (Su et al., 2017).

In the context of the presence of significant contradictions between the discovered results and the above-mentioned studies, as well as the absence of a general trend indicating the constancy of the results obtained in the studies investigating the problem, it seems that a careful analysis and interpretation of the obtained results are required. Firstly, the lack of significant effect of stretching conditions on the force-velocity profile suggests that stretching conditions applied might not have significantly altered the underlying mechanical properties of skeletal muscle contraction that contribute to imbalances in force and velocity capabilities as force-velocity profile characteristics are relatively stable and are influenced more by long-term training adaptations than by acute interventions (Jiménez-Reyes et al., 2017). Similarly, it is possible to state that maximum power output and peak torque are usually influenced by internal muscle properties and neural factors that might have been significantly altered by stretching methods applied, especially in well-trained individuals (Kuschel et al., 2022). As was stated above the participants recruited for the study were amateur CrossFit practitioners who likely were well familiar with ballistic and strength-based movements what potentially could make it more difficult for their neuromuscular systems to be susceptible enough to acute alterations from stretching protocols. Another important factor for the considerations is the specificity of the tests used. The squat jump test used to calculate participants' force-velocity profiles as well as the maximal voluntary isokinetic contraction test target specific aspects of performance that may not be as highly susceptible to physiological response of acute stimulation (resulting in significantly greater values) or blocking (resulting in significantly values) effects associated with stretching (Kay et al., 2015). In fact, jump performance as maximum height achieved is essentially a crude functional measure that reflects subtle changes in readiness or neuromuscular excitability. Whereas force-velocity imbalance, as well as peak torque or peak power, may require more substantial factors of muscle perturbation to detect statistically significant difference. One more possible explanation is related to the intensity and duration of the stretching protocols used in the study as moderate intensity and volume of the protocols used might have been insufficient to significantly affect force-velocity or strength measures.

In addition to the aforementioned factors some methodological aspects could have influenced the results obtained, hence be considered as limitations of the study. A sample size of 10 was used in the present study even though as was stated before post-hoc power analysis determined the sample size of 28 participants as sufficient and most of the studies conducted in the same field used a larger number of participants. This might have significantly impact the results obtain by limiting the statistical power to detect small to moderate effects, particularly for variables with higher inter-individual variability such as peak torque. Another limitation of the study is the fact that during the squat jump test, the depth of the half-squat position (initial crouch position) that the participants took before jumping was not strictly controlled, even though the participants were previously instructed in as much detail as possible about what position they needed to take. The depth of the jump could have affected the results of the jump height, as well as the muscle fatigue after the test, due to greater stretching of the muscle tissue with a deeper position taken. Hypothetically, the participants who took a deeper position during all five attempts could have experienced greater muscle fatigue, which could have subsequently affected the results obtained during the maximal voluntary isokinetic test. Another aspect that can be considered as a limitation is the fact that as CrossFit practitioners the participants were possibly more familiar with some of the movements performed during the tests than with other even though as was stated earlier the familiarization sessions were properly completed by each participant. Since CrossFit includes a wide variety of ballistic movement it is possible to assume that the participants were more familiar with the squat jump technique feeling more natural to perform than leg extension/flexion movement perform during the MVIC test.

From a practical standpoint, the findings suggest that dynamic stretching should be prioritized in CrossFit warm-ups, as it proved the most effective protocol among those tested, particularly for sessions or competitions requiring explosive power and ballistic actions. The significant improvement in squat jump height following dynamic stretching indicates that this method enhances neuromuscular readiness and supports maximum-effort performance without impairing force output. Moreover, the absence of negative effects on force–velocity imbalance, peak torque, power output, or peak power highlights its suitability for complex CrossFit movements such as the snatch, clean and jerk, and box jumps, where both strength and movement efficiency are crucial. Thus, dynamic stretching can be confidently included in warm-up routines without compromising key performance factors. While static stretching did not produce the same improvements, its lack of detrimental impact suggests that short-term static stretching, especially when combined with dynamic exercises, may not impair performance. Therefore, when the goal is to improve flexibility, static stretching can still be beneficial for movements requiring large ranges of motion, such as overhead squats or gymnastics elements commonly performed in CrossFit. Coaches and athletes should adapt warm-ups to the specific demands of training or competition—using dynamic stretching for explosive performance, and static stretching strategically to maintain or enhance flexibility without risking reductions in strength or power. For future research, it is recommended to investigate different variations of dynamic stretching, including sport-specific and ballistic techniques, as well as methods aimed at muscle potentiation. Future studies should also explore the horizontal force–

velocity profile to determine potential correlations between the vertical and horizontal effects of stretching on strength and power. Furthermore, improved control of the initial squat depth during jump testing is advised, using tools such as markers, lasers, or measuring tapes for consistency. Finally, incorporating countermovement jumps and physiological measures (e.g., muscle temperature, stiffness, and EMG activity) could provide deeper insight into the mechanisms by, which stretching influences performance outcomes.

The authors of the current study declare no professional relationships with companies or manufacturers who would benefit from the results of the present study. This research received no specific grant or financial support from any funding agency, commercial, or not-for-profit organization. The results of the present study do not constitute endorsement of any product by the authors or the National Strength and Conditioning Association (NSCA).

5. DECLARATION OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Reference

1. Araya-Ibacache, M., Aedo-Muñoz, E., Carreño-Ortiz, P., et al. (2022). Dynamic stretching increases the concentric rate of force development, but not jump height in female volleyball players. *Journal of Human Kinetics, 84*(1), 158–165.
2. Behm, D. G., Plewe, S., Grage, P., et al. (2011). Relative static stretch-induced impairments and dynamic stretch-induced enhancements are similar in young and middle-aged men. *Applied Physiology, Nutrition, and Metabolism, 36*(6), 790–797.
3. Carvalho, F. L., Carvalho, M. C., Simão, R., et al. (2012). Acute effects of a warm-up including active, passive, and dynamic stretching on vertical jump performance. *Journal of Strength and Conditioning Research, 26*(9), 2447–2452.
4. Claudino, J. G., Gabbett, T. J., Bourgeois, F., et al. (2018). CrossFit overview: A systematic review and meta-analysis. *Sports Medicine – Open, 4*, 1–14.
5. D'Hulst, G., Hodžić, D., Leuenberger, R., et al. (2024). Physiological profiles of male and female CrossFit athletes. *International Journal of Sports Physiology and Performance*, Advance online publication, 1–12.
6. Daneshjoo, A., Hosseini, E., Heshmati, S., et al. (2024). Effects of slow dynamic, fast dynamic, and static stretching on recovery of performance, range of motion, balance, and joint position sense in healthy adults. *BMC Sports Science, Medicine and Rehabilitation, 16*(1), 167.
7. Fiorilli, G., Quinzi, F., Buonsenso, A., et al. (2020). Does warm-up type matter? A comparison between traditional and functional inertial warm-up in young soccer players. *Journal of Functional Morphology and Kinesiology, 5*(4), 84.
8. Franco, B. L., Signorelli, G. R., Trajano, G. S., et al. (2008). Acute effects of different stretching exercises on muscular endurance. *Journal of Strength and Conditioning Research, 22*(6), 1832–1837.
9. Fukutani, A., Shimoho, K., & Isaka, T. (2019). Pre-activation affects the effect of stretch-shortening cycle by modulating fascicle behavior. *Biology Open, 8*(12), bio044651.
10. Habets, B., Staal, J. B., Tijssen, M., et al. (2018). Intrarater reliability of the Humac NORM isokinetic dynamometer for strength measurements of the knee and shoulder muscles. *BMC Research Notes, 11*, 1–5.
11. Hughes, S., Warmenhoven, J., Haff, G. G., et al. (2022). Countermovement jump and squat jump force-time curve analysis in control and fatigue conditions. *Journal of Strength and Conditioning Research, 36*(10), 2752–2761.
12. Jiménez-Reyes, P., Samozino, P., Brughelli, M., & Morin, J. B. (2017). Effectiveness of an individualized training based on force–velocity profiling during jumping. *Frontiers in Physiology, 7*, 677.
13. Kay, A. D., Husbands-Beasley, J., & Blazevich, A. J. (2015). Effects of contract–relax, static stretching, and isometric contractions on muscle–tendon mechanics. *Medicine and Science in Sports and Exercise, 47*(10), 2181–2190.
14. Kirmizigil, B., Ozcaldiran, B., & Colakoglu, M. (2014). Effects of three different stretching techniques on vertical jumping performance. *Journal of Strength and Conditioning Research, 28*(5), 1263–1271.

ISSN (Print): 3080-0307 ISSN (Online): 3107-037X DOI: https://doi.org/10.63750/asah5n55

15. Kruse, N. T., Barr, M. W., Gilders, R. M., et al. (2015). Effect of different stretching strategies on the kinetics of vertical jumping in female volleyball athletes. *Journal of Sport and Health Science, 4*(4), 364–370.
16. Kuschel, L. B., Sonnenburg, D., & Engel, T. (2022). Factors of muscle quality and determinants of muscle strength: A systematic literature review. *Healthcare, 10*(10), 1937.
17. Mahrová, A., Hráský, P., & Zahálka, F. (2014). The effect of two types of stretching on flexibility in selected joints in youth soccer players. *Acta Gymnica, 44*(1), 23–32.
18. Mangine, G. T., Tankersley, J. E., McDougle, J. M., et al. (2020). Predictors of CrossFit Open performance. *Sports, 8*(7), 102.
19. Martínez-Gómez, R., Valenzuela, P. L., Alejo, L. B., et al. (2020). Physiological predictors of competition performance in CrossFit athletes. *International Journal of Environmental Research and Public Health, 17*(10), 3699.
20. Matsuo, S., Iwata, M., Miyazaki, M., et al. (2023). Acute and prolonged effects of 300 s of static, dynamic, and combined stretching on flexibility and muscle force. *Journal of Sports Science and Medicine, 22*(4), 626–634.
21. Matsuo, S., Suzuki, S., Iwata, M., et al. (2013). Acute effects of different stretching durations on passive torque, mobility, and isometric muscle force. *Journal of Strength and Conditioning Research, 27*(12), 3367–3376.
22. Meyer, J., Morrison, J., & Zuniga, J. (2017). The benefits and risks of CrossFit: A systematic review. *Workplace Health and Safety, 65*(12), 612–618.
23. Özdemir, U., Yavuz, S., Koç, M. A., et al. (2024). Effectiveness and importance of warm-up protocols and stretching exercises. *Interdisciplinary Approaches in Sport Sciences*, 93–102.
24. Pacheco, L., Balius, R., Aliste, L., et al. (2011). The acute effects of different stretching exercises on jump performance. *Journal of Strength and Conditioning Research, 25*(11), 2991–2998.
25. Parpa, K., & Michaelides, M. (2022). Anthropometric, strength, and aerobic fitness of higher- and lower-level soccer referees. *International Journal of Sports Science, 12*(1), 8–13.
26. Perrier, E. T., Pavol, M. J., & Hoffman, M. A. (2011). The acute effects of a warm-up including static or dynamic stretching on countermovement jump height, reaction time, and flexibility. *Journal of Strength and Conditioning Research, 25*(7), 1925–1931.
27. Samozino, P., Edouard, P., Sangnier, S., et al. (2014). Force–velocity profile: Imbalance determination and effect on lower limb ballistic performance. *International Journal of Sports Medicine, 35*(6), 505–510.
28. Samozino, P., Morin, J. B., Hintzy, F., & Belli, A. (2008). A simple method for measuring force, velocity, and power output during squat jump. *Journal of Biomechanics, 41*(14), 2940–2945.
29. Sauvé, B., Haugan, M., & Paulsen, G. (2024). Physical and physiological characteristics of elite CrossFit athletes. *Sports, 12*(6), 162.

30. Silva, L. M., Neiva, H. P., Marques, M. C., Izquierdo, M., & Marinho, D. A. (2018). Effects of warm-up, post-warm-up, and re-warm-up strategies on explosive efforts in team sports: A systematic review. *Sports Medicine, 48*, 2285–2299.
31. Su, H., Chang, N. J., Wu, W. L., Guo, L. Y., & Chu, I. H. (2017). Acute effects of foam rolling, static stretching, and dynamic stretching during warm-ups on muscular flexibility and strength in young adults. *Journal of Sport Rehabilitation, 26*(6), 469–477.
32. Thomas, S., Reading, J., & Shephard, R. J. (1992). Revision of the Physical Activity Readiness Questionnaire (PAR-Q). *Canadian Journal of Sport Sciences, 17*(4), 338–345.
33. Turki, O., Chaouachi, A., Drinkwater, E. J., et al. (2011). Ten minutes of dynamic stretching is sufficient to potentiate vertical jump performance characteristics. *Journal of Strength and Conditioning Research, 25*(9), 2453–2463.
34. Wallmann, H. W., Christensen, S. D., Perry, C., et al. (2012). The acute effects of various types of stretching—static, dynamic, ballistic, and no stretch—of the iliopsoas on 40-yard sprint times in recreational runners. *International Journal of Sports Physical Therapy, 7*(5), 540–545.
35. World Medical Association. (2008). *Declaration of Helsinki: Ethical principles for medical research involving human subjects*.

 ISSN (Print): 3080-0307
ISSN (Online): 3107-037X
DOI: https://doi.org/10.63750/asah5n55

6. APPENDICIES

Appendix A

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.

GENERAL HEALTH QUESTIONS

Please read the 7 questions below carefully and answer each one honestly: check YES or NO.	YES	NO
1) Has your doctor ever said that you have a heart condition ☐ **OR** high blood pressure ☐?	☐	☑
2) Do you feel pain in your chest at rest, during your daily activities of living, **OR** when you do physical activity?	☐	☑
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).	☐	☑
4) Have you ever been diagnosed with another chronic medical condition (other than heart disease or high blood pressure)? **PLEASE LIST CONDITION(S) HERE:** ______	☐	☑
5) Are you currently taking prescribed medications for a chronic medical condition? **PLEASE LIST CONDITION(S) AND MEDICATIONS HERE:** ______	☐	☑
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:** ______	☐	☑
7) Has your doctor ever said that you should only do medically supervised physical activity?	☐	☑

☑ **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
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.

NAME Sergei Binder DATE 10.01.2025

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 are currently experiencing a temporary illness, such as a cold or fever. It is best to wait until you feel better.
- You are pregnant. In this case, talk with your health care practitioner, physician, qualified exercise professional, and/or complete the ePARmed-X+ at www.eparmedx.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 health care practitioner, physician, or qualified exercise professional before proceeding with any physical activity program.

 1 / 4
01-11-2023

Appendix B

University of Central Lancashire (UCLan Cyprus) – Cyprus Campus
Sport and Exercise Science

Participant Consent Form

Study Title: Acute effect of different stretching protocols on strength, power and force-velocity profile of adult amateur CrossFit practitioners in Cyprus

Researcher Name: Anton Chernov

Supervisor Name: Dr. Koulla Parpa

Introduction

You are invited to participate in a research study conducted as part of a student's academic requirements. Before you decide whether to take part, it is important that you understand why the research is being done and what it will involve. Please take time to read the following information carefully.

Purpose of the Study

Investigation of the acute effect of different stretching protocols on maximal strength, power and force-velocity imbalance among adult amateur CrossFit practitioners.

Voluntary Participation

Your participation in this study is entirely voluntary. You are free to decline to participate or to withdraw from the study at any time without giving a reason and without any consequences. You may withdraw in the case of emergency or due to private circumstances.

Procedures

If you decide to take part, you will be asked to perform squat jump and maximal voluntary isokinetic contraction tests.

Risks and Discomforts

Any risks or potential discomfort associated with this study will be explained to you in advance. Reasonable measures will be taken to minimize these risks.

Benefits

Although you may not receive direct benefits, your participation will contribute to the advancement of knowledge in sport and exercise science.

Confidentiality

All information collected about you during the study will be kept strictly confidential. Your identity will not be revealed in any publication or report.

University of Central Lancashire
UCLan

Right to Withdraw

In accordance with the Declaration of Helsinki (WMA General Assembly, 2008), you have the right to withdraw from this research at any time, without penalty or loss of benefits to which you are otherwise entitled.

Further Information

If you require any further information or have questions about the study, please contact:

- **Researcher:** Anton Chernov (AChernov@uclan.ac.uk)
- **Supervisor:** Dr. Koulla Parpa (KParpa@uclan.ac.uk)

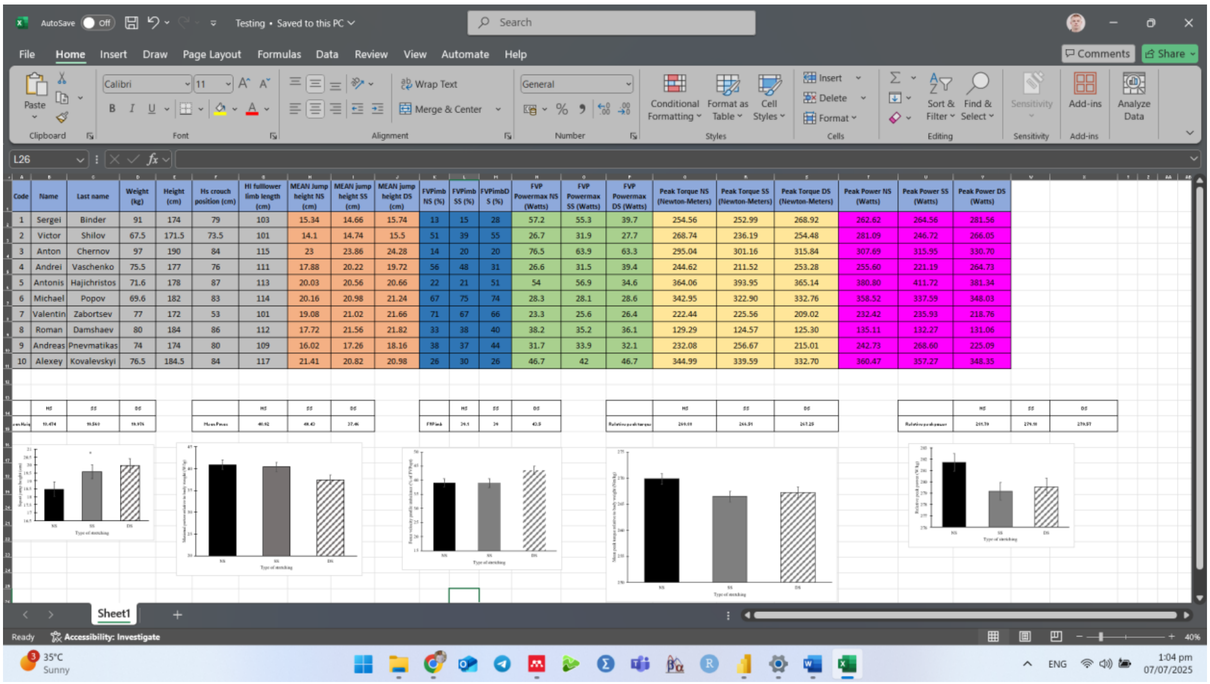
Consent Declaration

I have read and understood the information provided above. I have had the opportunity to ask questions, and all my questions have been answered to my satisfaction. I voluntarily agree to participate in this study.

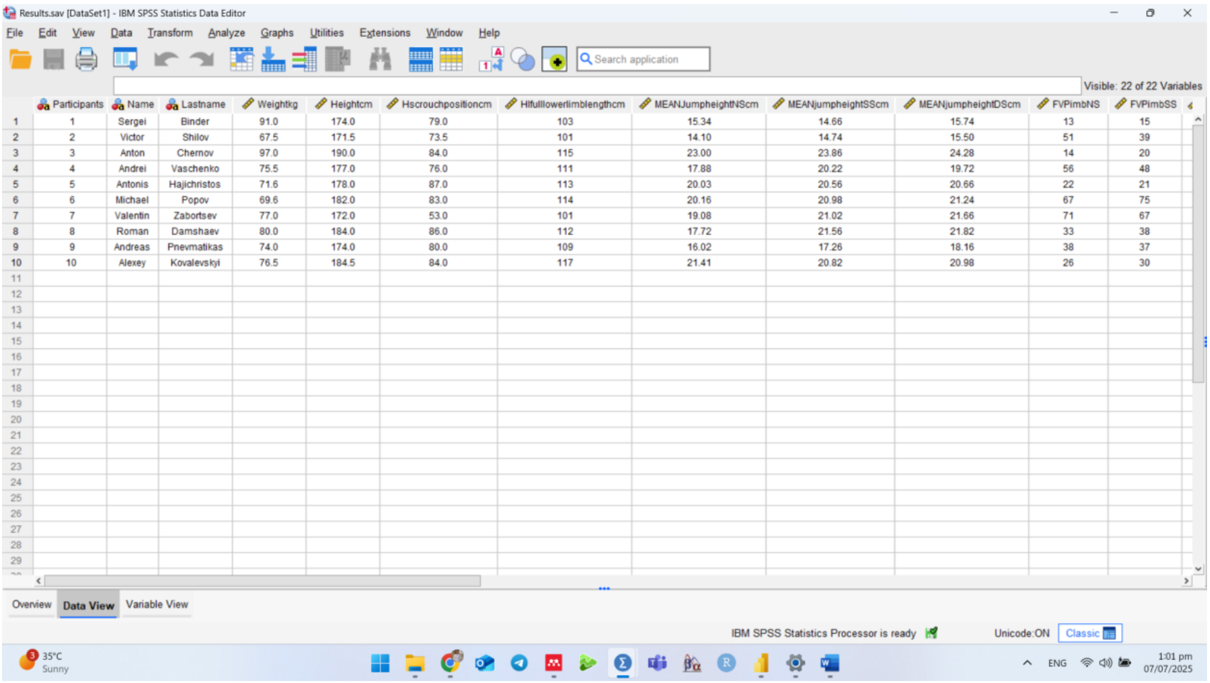
Participant's name: Sergei Binder
Participant's Signature: ____________________________
Date: 10.01.2025

Researcher's name: Anton Chernov
Researcher's Signature: ____________________________
Date: 10.01.2025

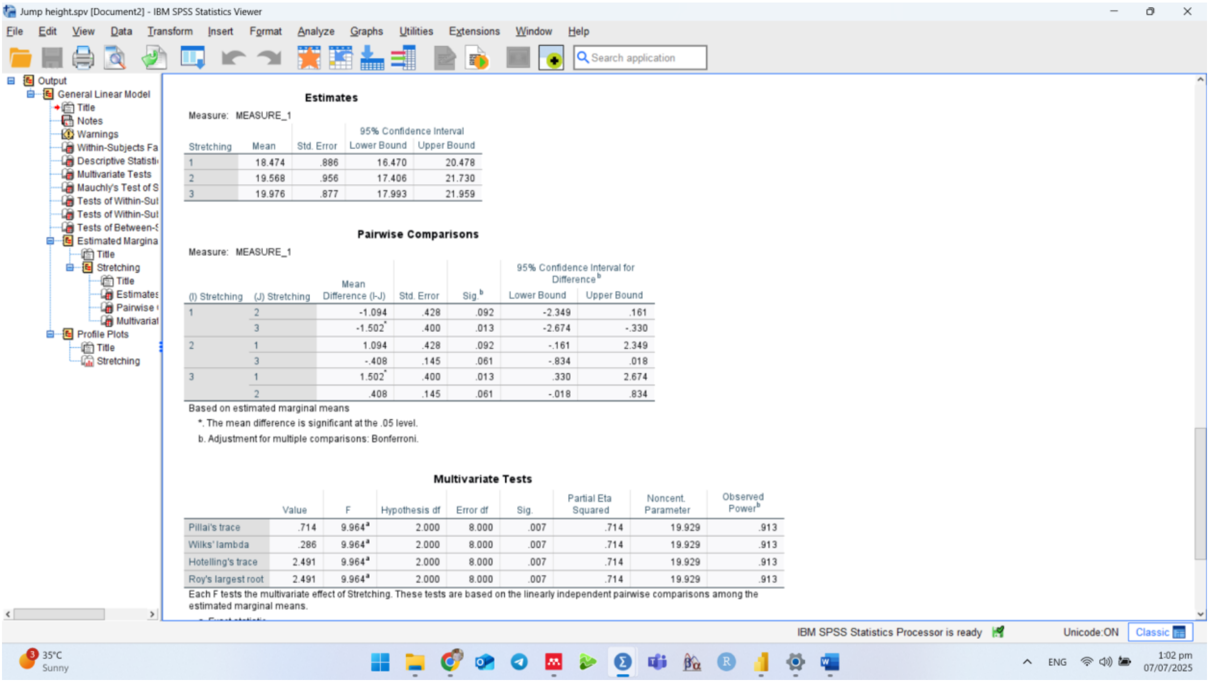
Appendix C



Code	Name	Last name	Weight (kg)	Height (cm)	Hs crouch position (cm)	Hl fulllower limb length (cm)	MEAN Jump height NS (cm)	MEAN jump height SS (cm)	MEAN jump height DS (cm)	FVPimb NS (%)	FVPimb SS (%)	FVPimbDS (%)	FVP Powermax NS (Watts)	FVP Powermax SS (Watts)	FVP Powermax DS (Watts)	Peak Torque NS (Newton-Meters)	Peak Torque SS (Newton-Meters)	Peak Torque DS (Newton-Meters)	Peak Power NS (Watts)	Peak Power SS (Watts)	Peak Power DS (Watts)
1	Sergei	Binder	91	174	79	103	15.34	14.66	15.74	13	15	28	57.2	55.3	39.7	254.56	252.99	268.92	262.62	264.56	281.56
2	Victor	Shilov	67.5	171.5	73.5	101	14.1	14.74	15.5	51	39	55	26.7	31.9	27.7	268.74	236.19	254.48	281.09	246.72	266.05
3	Anton	Chernov	97	190	84	115	23	23.86	24.28	14	20	20	76.5	63.9	63.3	295.04	301.16	315.84	307.69	315.95	330.70
4	Andrei	Vaschenko	75.5	177	76	111	17.88	20.22	19.72	56	48	31	26.6	31.5	39.4	244.62	211.52	253.28	255.60	221.19	264.73
5	Antonis	Hajichristos	71.6	178	87	113	20.03	20.56	20.66	22	21	51	54	56.9	34.6	364.06	393.95	365.14	380.80	411.72	381.34
6	Michael	Popov	69.6	182	83	114	20.16	20.98	21.24	67	75	74	28.3	28.1	28.6	342.95	322.90	332.76	358.52	337.59	348.03
7	Valentin	Zabortsev	77	172	53	101	19.08	21.02	21.66	71	67	66	23.3	25.6	26.4	222.44	225.56	209.02	232.42	235.93	218.76
8	Roman	Damshaev	80	184	86	112	17.72	21.56	21.82	33	38	40	38.2	35.2	36.1	129.29	124.57	125.30	135.11	132.27	131.06
9	Andreas	Pnevmatikas	74	174	80	109	16.02	17.26	18.16	38	37	44	31.7	33.9	32.1	232.08	256.67	215.01	242.73	268.60	225.09
10	Alexey	Kovalevskyi	76.5	184.5	84	117	21.41	20.82	20.98	26	30	26	46.7	42	46.7	344.99	339.59	332.70	360.47	357.27	348.35



	Participants	Name	Lastname	Weightkg	Heightcm	Hscrouchpositioncm	Hlfulllowerlimblengthcm	MEANJumpheightNScm	MEANjumpheightSScm	MEANjumpheightDScm	FVPimbNS	FVPimbSS
1	1	Sergei	Binder	91.0	174.0	79.0	103	15.34	14.66	15.74	13	15
2	2	Victor	Shilov	67.5	171.5	73.5	101	14.10	14.74	15.50	51	39
3	3	Anton	Chernov	97.0	190.0	84.0	115	23.00	23.86	24.28	14	20
4	4	Andrei	Vaschenko	75.5	177.0	76.0	111	17.88	20.22	19.72	56	48
5	5	Antonis	Hajichristos	71.6	178.0	87.0	113	20.03	20.56	20.66	22	21
6	6	Michael	Popov	69.6	182.0	83.0	114	20.16	20.98	21.24	67	75
7	7	Valentin	Zabortsev	77.0	172.0	53.0	101	19.08	21.02	21.66	71	67
8	8	Roman	Damshaev	80.0	184.0	86.0	112	17.72	21.56	21.82	33	38
9	9	Andreas	Pnevmatikas	74.0	174.0	80.0	109	16.02	17.26	18.16	38	37
10	10	Alexey	Kovalevskyi	76.5	184.5	84.0	117	21.41	20.82	20.98	26	30



Estimates

Measure: MEASURE_1

Stretching	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1	18.474	.886	16.470	20.478
2	19.568	.956	17.406	21.730
3	19.976	.877	17.993	21.959

Pairwise Comparisons

Measure: MEASURE_1

(I) Stretching	(J) Stretching	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b] Lower Bound	Upper Bound
1	2	-1.094	.428	.092	-2.349	.161
	3	-1.502*	.400	.013	-2.674	-.330
2	1	1.094	.428	.092	-.161	2.349
	3	-.408	.145	.061	-.834	.018
3	1	1.502*	.400	.013	.330	2.674
	2	.408	.145	.061	-.018	.834

Based on estimated marginal means

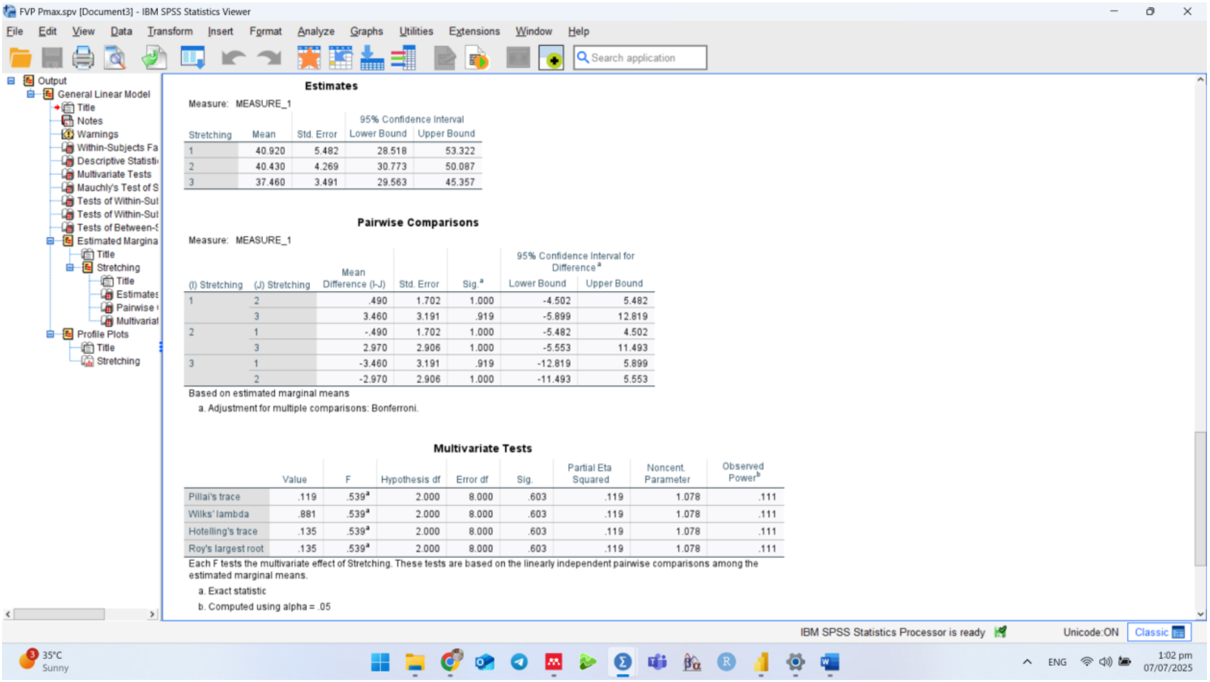
*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

Multivariate Tests

	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
Pillai's trace	.714	9.964[a]	2.000	8.000	.007	.714	19.929	.913
Wilks' lambda	.286	9.964[a]	2.000	8.000	.007	.714	19.929	.913
Hotelling's trace	2.491	9.964[a]	2.000	8.000	.007	.714	19.929	.913
Roy's largest root	2.491	9.964[a]	2.000	8.000	.007	.714	19.929	.913

Each F tests the multivariate effect of Stretching. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means.



Estimates

Measure: MEASURE_1

Stretching	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1	40.920	5.482	28.518	53.322
2	40.430	4.269	30.773	50.087
3	37.460	3.491	29.563	45.357

Pairwise Comparisons

Measure: MEASURE_1

(I) Stretching	(J) Stretching	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a] Lower Bound	Upper Bound
1	2	.490	1.702	1.000	-4.502	5.482
	3	3.460	3.191	.919	-5.899	12.819
2	1	-.490	1.702	1.000	-5.482	4.502
	3	2.970	2.906	1.000	-5.553	11.493
3	1	-3.460	3.191	.919	-12.819	5.899
	2	-2.970	2.906	1.000	-11.493	5.553

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

Multivariate Tests

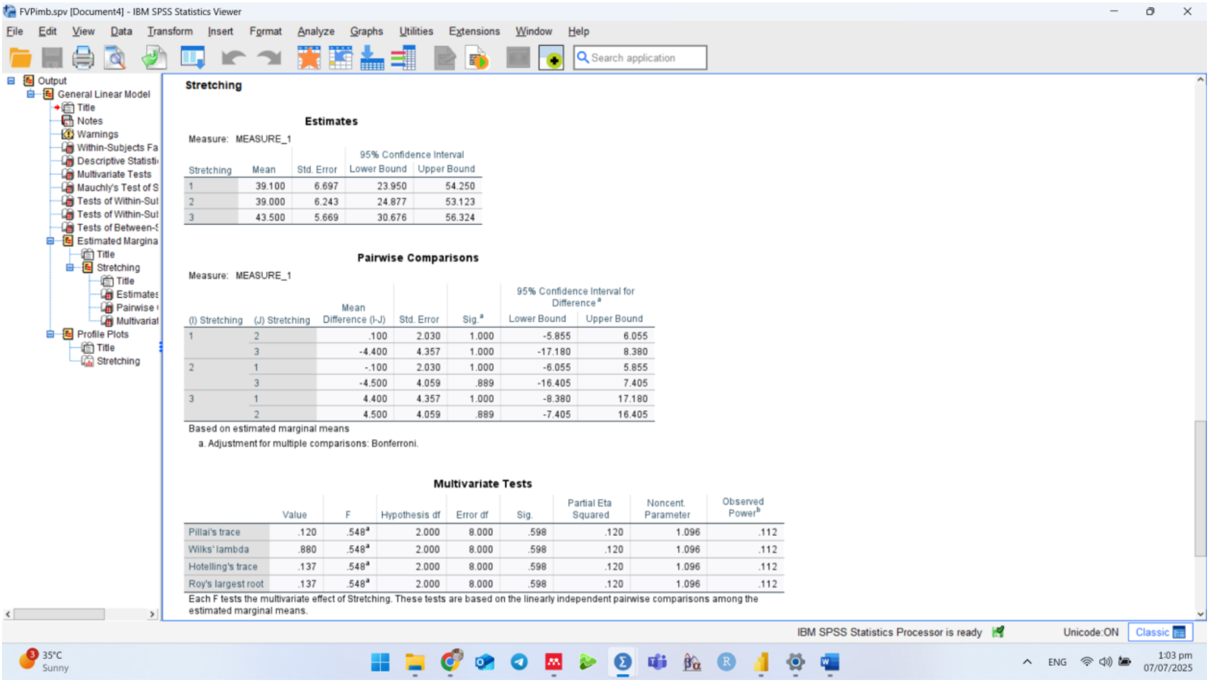
	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
Pillai's trace	.119	.539[a]	2.000	8.000	.603	.119	1.078	.111
Wilks' lambda	.881	.539[a]	2.000	8.000	.603	.119	1.078	.111
Hotelling's trace	.135	.539[a]	2.000	8.000	.603	.119	1.078	.111
Roy's largest root	.135	.539[a]	2.000	8.000	.603	.119	1.078	.111

Each F tests the multivariate effect of Stretching. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Exact statistic

b. Computed using alpha = .05

 ISSN (Print): 3080-0307 DOI: https://doi.org/10.63750/asah5n55
ISSN (Online): 3107-037X



Stretching

Estimates

Measure: MEASURE_1

Stretching	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1	39.100	6.697	23.950	54.250
2	39.000	6.243	24.877	53.123
3	43.500	5.669	30.676	56.324

Pairwise Comparisons

Measure: MEASURE_1

(I) Stretching	(J) Stretching	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a] Lower Bound	95% Confidence Interval for Difference[a] Upper Bound
1	2	.100	2.030	1.000	-5.855	6.055
	3	-4.400	4.357	1.000	-17.180	8.380
2	1	-.100	2.030	1.000	-6.055	5.855
	3	-4.500	4.059	.889	-16.405	7.405
3	1	4.400	4.357	1.000	-8.380	17.180
	2	4.500	4.059	.889	-7.405	16.405

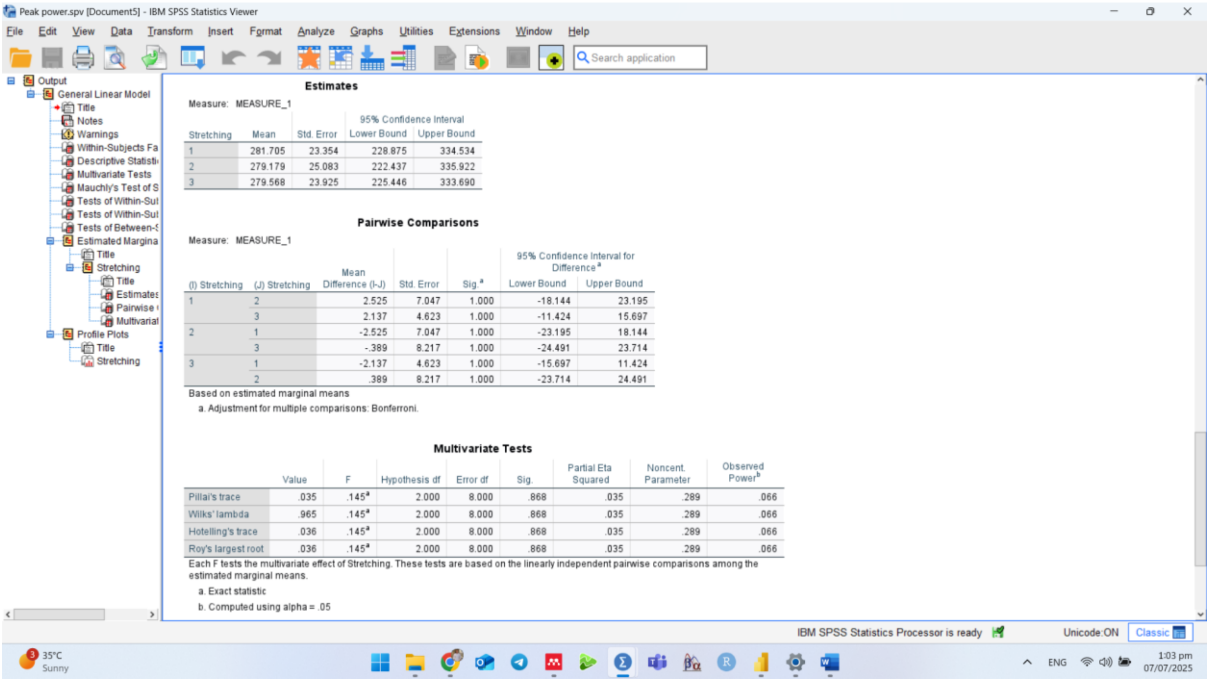
Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

Multivariate Tests

	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
Pillai's trace	.120	.548[a]	2.000	8.000	.598	.120	1.096	.112
Wilks' lambda	.880	.548[a]	2.000	8.000	.598	.120	1.096	.112
Hotelling's trace	.137	.548[a]	2.000	8.000	.598	.120	1.096	.112
Roy's largest root	.137	.548[a]	2.000	8.000	.598	.120	1.096	.112

Each F tests the multivariate effect of Stretching. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means.



Estimates

Measure: MEASURE_1

Stretching	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1	281.705	23.354	228.875	334.534
2	279.179	25.083	222.437	335.922
3	279.568	23.925	225.446	333.690

Pairwise Comparisons

Measure: MEASURE_1

(I) Stretching	(J) Stretching	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a] Lower Bound	95% Confidence Interval for Difference[a] Upper Bound
1	2	2.525	7.047	1.000	-18.144	23.195
	3	2.137	4.623	1.000	-11.424	15.697
2	1	-2.525	7.047	1.000	-23.195	18.144
	3	-.389	8.217	1.000	-24.491	23.714
3	1	-2.137	4.623	1.000	-15.697	11.424
	2	.389	8.217	1.000	-23.714	24.491

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

Multivariate Tests

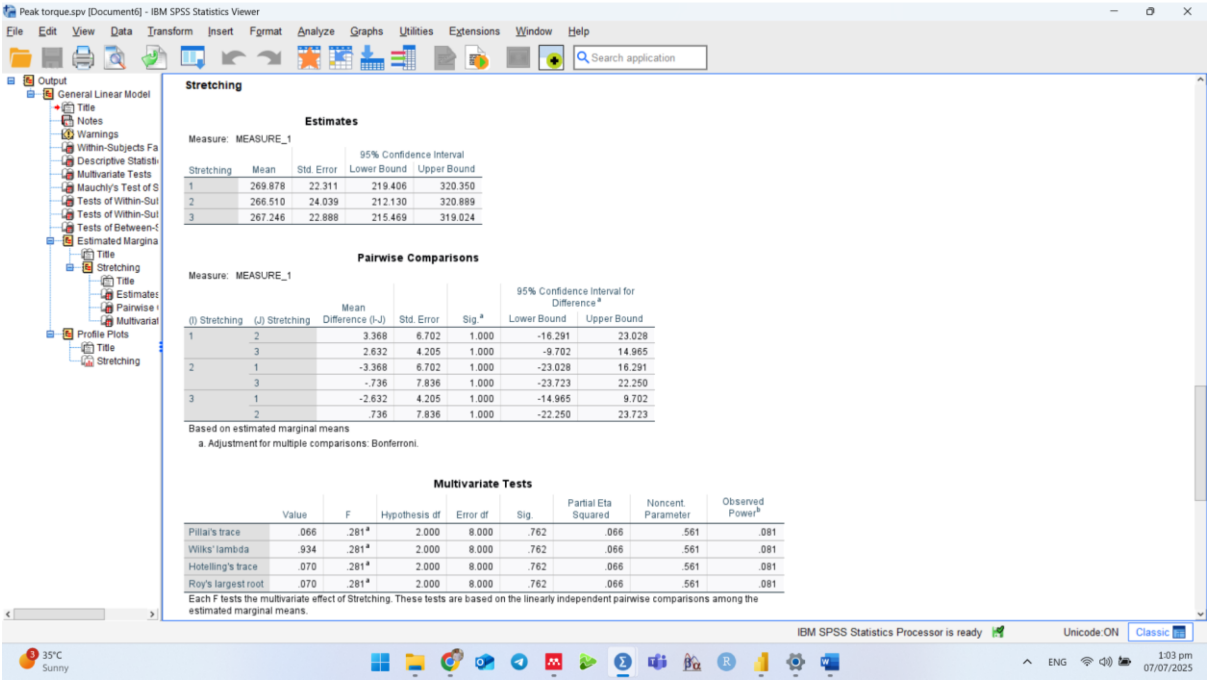
	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
Pillai's trace	.035	.145[a]	2.000	8.000	.868	.035	.289	.066
Wilks' lambda	.965	.145[a]	2.000	8.000	.868	.035	.289	.066
Hotelling's trace	.036	.145[a]	2.000	8.000	.868	.035	.289	.066
Roy's largest root	.036	.145[a]	2.000	8.000	.868	.035	.289	.066

Each F tests the multivariate effect of Stretching. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Exact statistic

b. Computed using alpha = .05

 ISSN (Print): 3080-0307 ISSN (Online): 3107-037X DOI: https://doi.org/10.63750/asah5n55



Stretching

Estimates

Measure: MEASURE_1

Stretching	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1	269.878	22.311	219.406	320.350
2	266.510	24.039	212.130	320.889
3	267.246	22.888	215.469	319.024

Pairwise Comparisons

Measure: MEASURE_1

(I) Stretching	(J) Stretching	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a] Lower Bound	95% Confidence Interval for Difference[a] Upper Bound
1	2	3.368	6.702	1.000	-16.291	23.028
	3	2.632	4.205	1.000	-9.702	14.965
2	1	-3.368	6.702	1.000	-23.028	16.291
	3	-.736	7.836	1.000	-23.723	22.250
3	1	-2.632	4.205	1.000	-14.965	9.702
	2	.736	7.836	1.000	-22.250	23.723

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

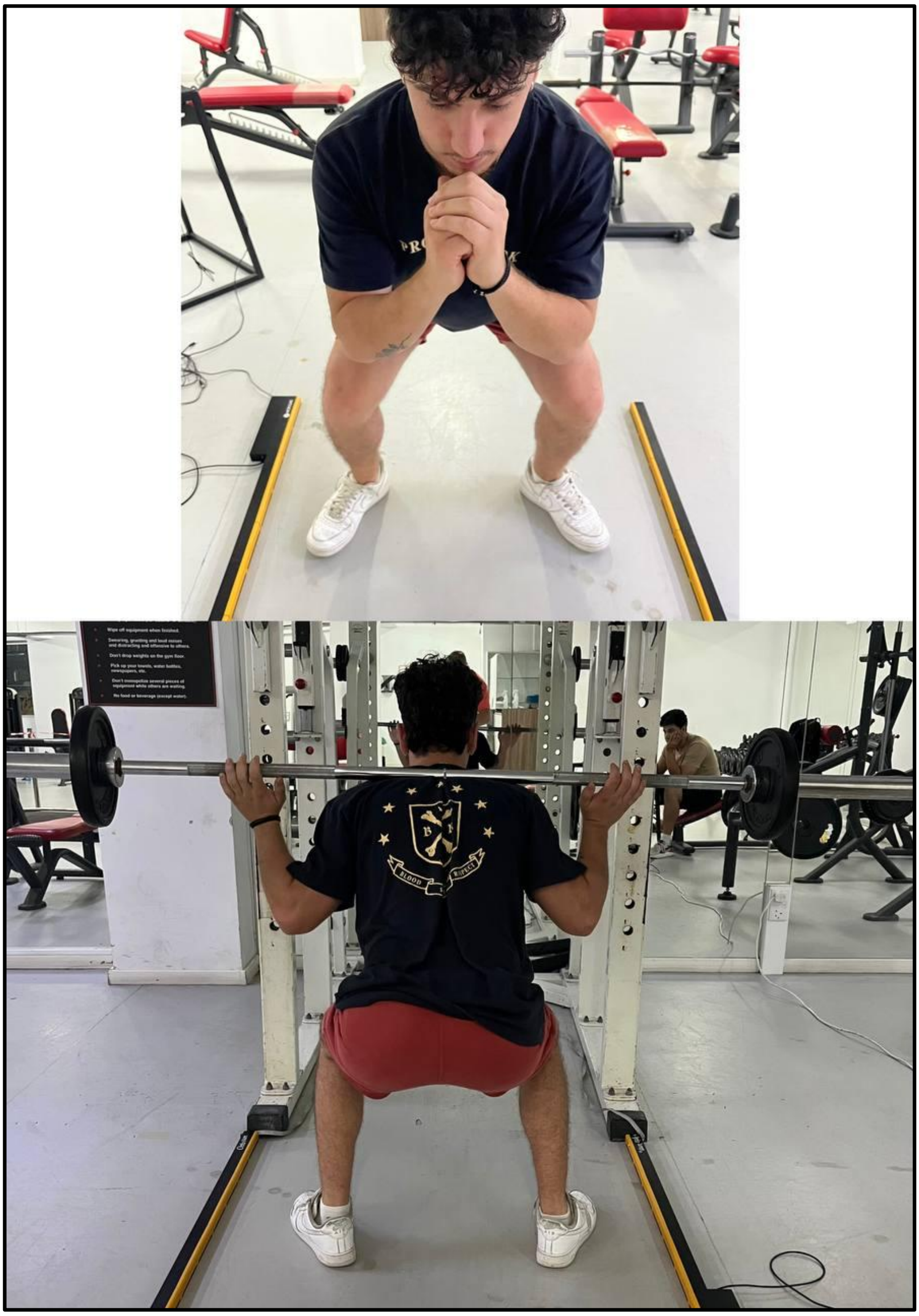
Multivariate Tests

	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
Pillai's trace	.066	.281[a]	2.000	8.000	.762	.066	.561	.081
Wilks' lambda	.934	.281[a]	2.000	8.000	.762	.066	.561	.081
Hotelling's trace	.070	.281[a]	2.000	8.000	.762	.066	.561	.081
Roy's largest root	.070	.281[a]	2.000	8.000	.762	.066	.561	.081

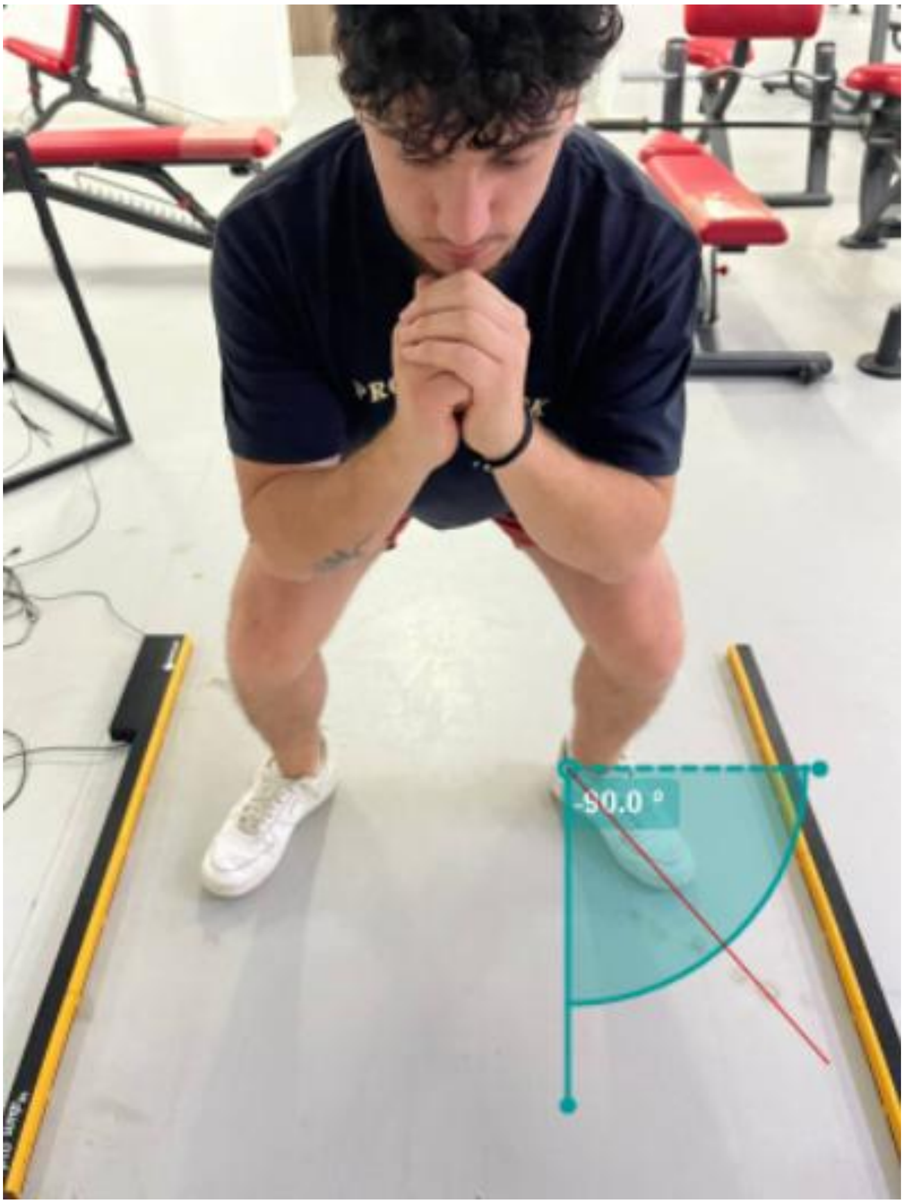
Each F tests the multivariate effect of Stretching. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means.

ISSN (Print): 3080-0307 DOI: https://doi.org/10.63750/asah5n55
ISSN (Online): 3107-037X

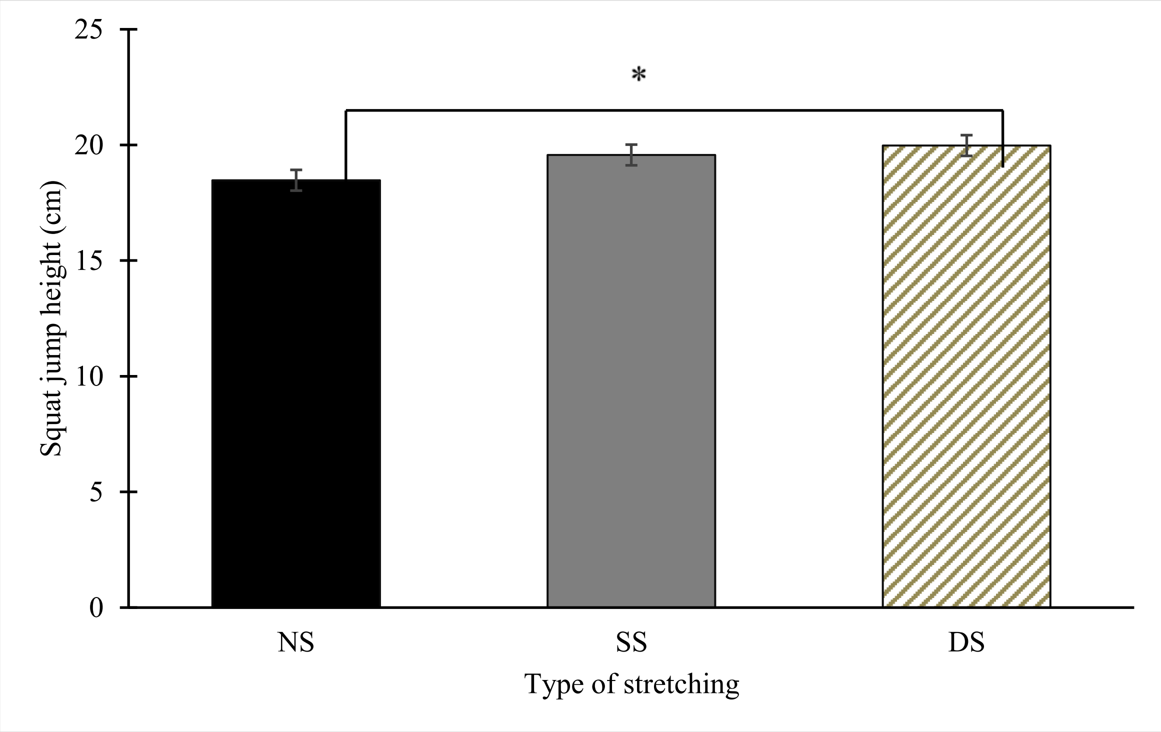
7. FIGURES

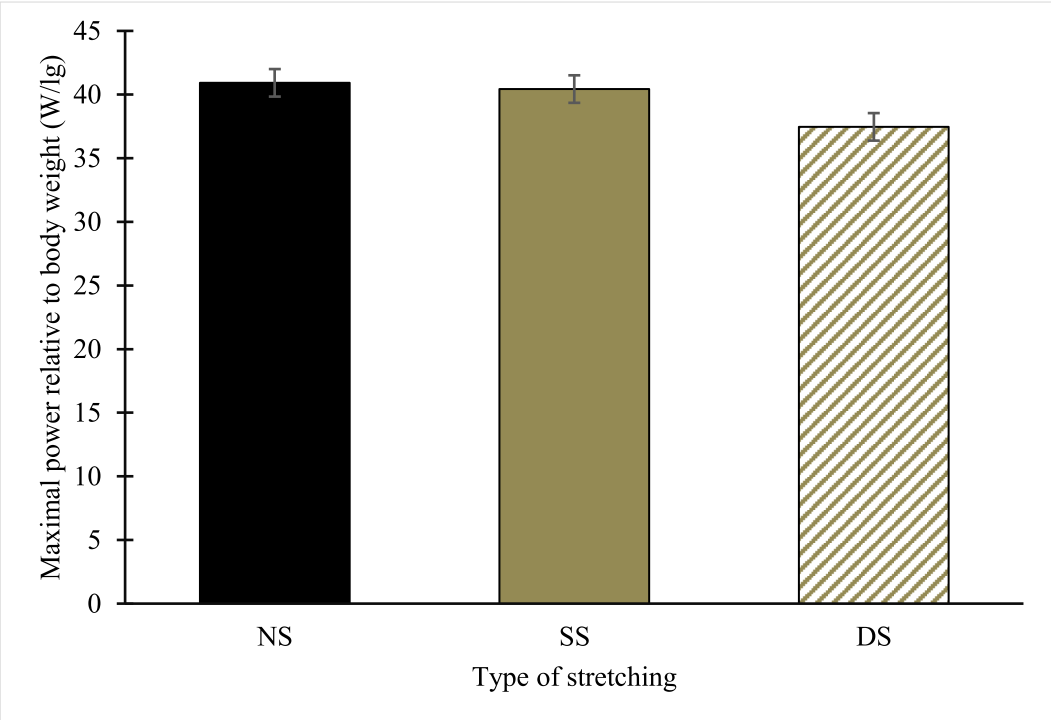



-55.8 °
-91.3 °

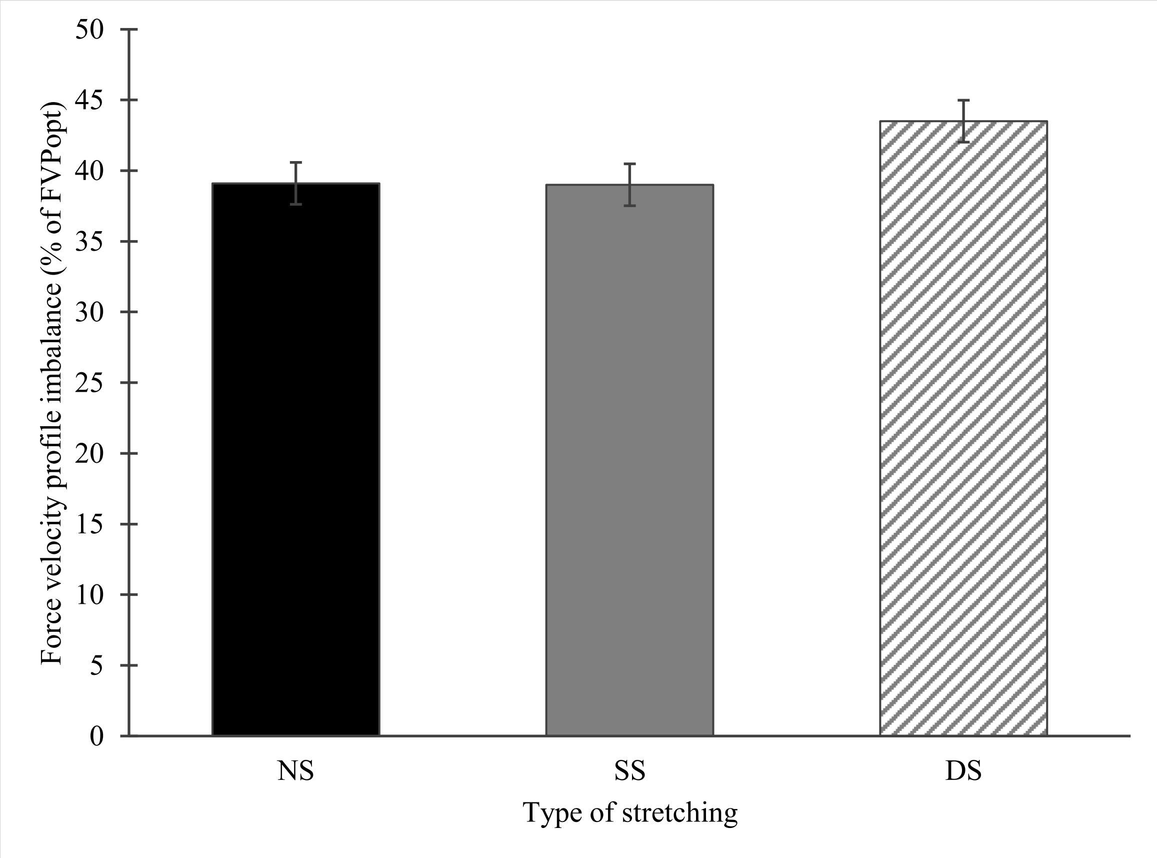

-90.0 °

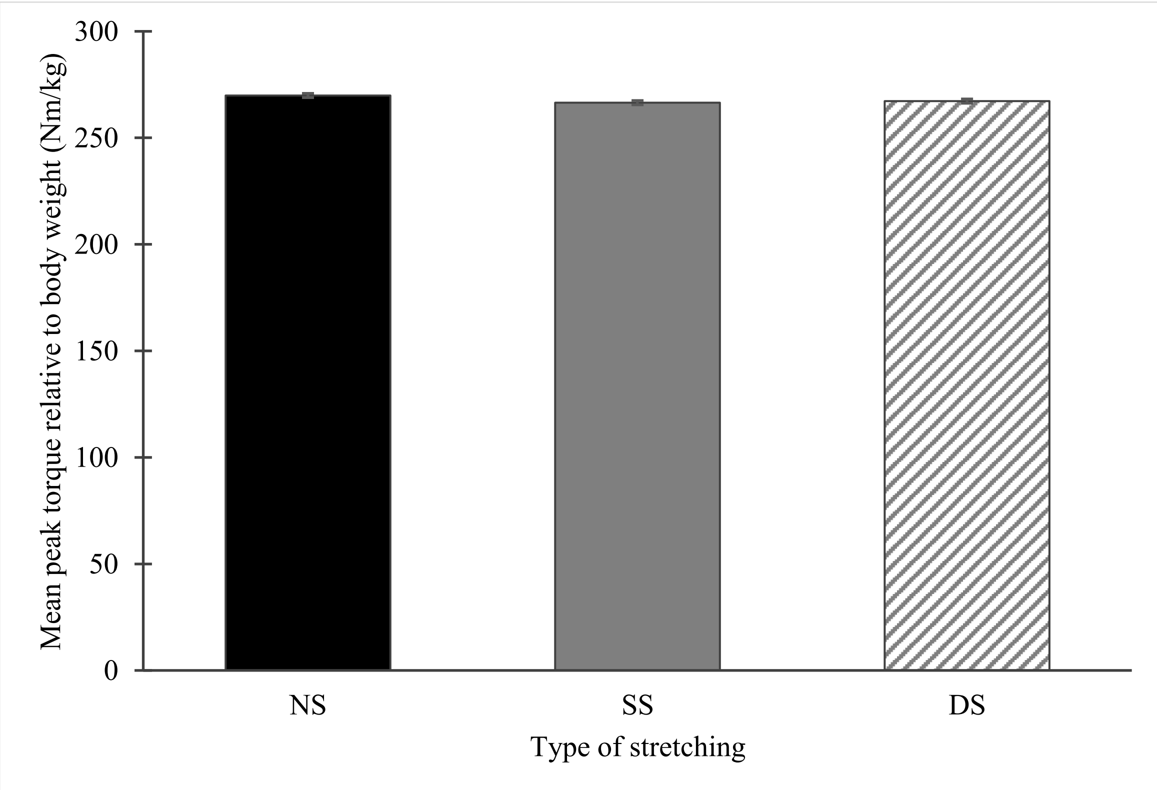
ISSN (Print): 3080-0307
ISSN (Online): 3107-037X
DOI: https://doi.org/10.63750/asah5n55

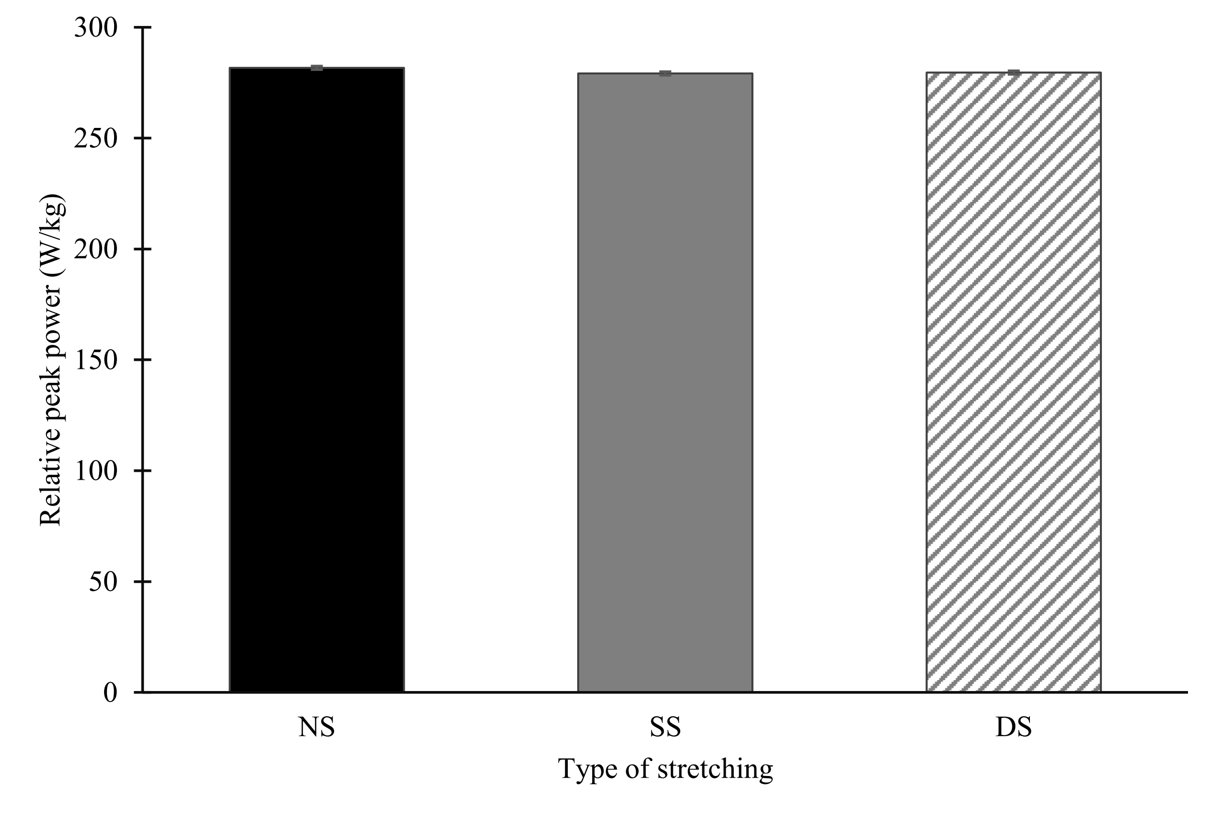




The Global Journal of Sport and Exercise Science (GJSES) ISSN (Print): 3080-0307 ISSN (Online): 3107-037X DOI: https://doi.org/10.63750/asah5n55







8. FIGURE CAPTURES

Figure 1. Anthropometric measurements of the participant before tests.
Figure 2. Initial positions under unloaded and loaded conditions.
Figure 3. Crouch position taken before execution of SJ.
Figure 4. Static stretching exercises
Figure 5. Angles of the hip and knee joints at the crouch position
Figure 6. Feet angles at the crouch position
Figure 7. Mean values of the SJ height with standard deviation error bars. *- significant difference ($p<.05$).
Figure 8. Mean values of the Pmax relative to body weight with standard deviation error bars.
Figure 9. Mean values of the FVPimb with standard deviation error bars.
Figure 10. Mean values of the peak torque relative to body weight with standard deviation error bars.
Figure 11. Mean values of the peak power relative to body weight with standard deviation error bars.