**Investigating the Impact of Stretching Techniques on Vertical Jump Performance**

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# Abstract

# This study investigated the effects of static stretching (SS) and dynamic stretching (DS) on vertical jump performance using a randomised controlled cross-over design. A total of 11 physically active participants, aged 21 to 30, performed three stretching protocols: static stretching, dynamic stretching, and a no-stretch control. Vertical jump height was measured pre- and post-stretch using a modified Sergant jump test. The results showed that dynamic stretching led to the greatest improvement in vertical jump height (mean increase of 4.00 cm), followed by static stretching (3.45 cm), while the control condition showed minimal improvement (1.91 cm). ANOVA revealed a significant difference between the dynamic and control conditions (*p* < .05), while the difference between static stretching and control was marginally significant (*p* = .102). These findings suggest that dynamic stretching may be the most effective warm-up strategy for improving vertical jump performance, providing valuable insights for athletes and coaches aiming to enhance explosive power.

*Keywords:* Dynamic stretch, Sergant, vertical jump, power

# Introduction

Stretching is deemed to be a critical aspect of athletic preparation and performance, particularly in activities requiring explosive power and sudden changes in speed and direction. To help get blood moving through the muscle and also reduce the potential for injury. The ability to generate forceful movements through the body, beginning in the lower, can be measured through vertical jump height; this provides some essential insights into an individual’s muscular strength, coordination, and motor control. Vertical jump performance is not only a valuable metric for athletes in sports like basketball and volleyball, but it also plays a significant role in everyday functional tasks, such as climbing stairs, lifting objects, and maintaining overall mobility.

Research has previously explored the effects of different stretching protocols on vertical jump performance, particularly the comparison between static stretching (SS) and dynamic stretching (DS). Static stretching typically involves holding a muscle in an elongated position for an extended period, usually between 10 to 30 seconds. This method has been shown to improve flexibility and increase range of motion, but recent studies suggest that it may have a negating effect on activities requiring explosive power. Conversely, dynamic stretching involves controlled, repetitive movements that mimic the activity to be performed. This type of stretching increases blood flow enhances activation of the muscles, and has been shown to better prepare athletes for power-based movements.

For instance, Fletcher's (2010) study demonstrated that fast dynamic stretching had a more significant positive impact on vertical jump performance compared to slower dynamic stretching, suggesting that the velocity of stretching movements can influence performance outcomes. This highlights the importance of not only the type of stretching but also the intensity and speed at which it is performed. Similarly, Behm and colleagues (2001) emphasised the role of the stretch-shortening cycle (SSC) in enhancing dynamic performance, including jumping, by optimising force production and energy efficiency during muscle contraction.

Furthermore, the use of ballistic stretching, a more aggressive form of dynamic stretching, has been shown to be more effective than static stretching in improving jump performance, particularly in trained athletes. Bacurau et al. (2009) found that ballistic stretching led to greater improvements in flexibility and jump height in a group of trained runners. These findings support the notion that dynamic movements that replicate the intensity of the sport or activity may be superior for preparing the body for high-power outputs.

The inclusion of arm swings in dynamic movements has also been shown to significantly increase jump height by further optimising the SSC, as noted by Gillen et al. (2022). Their research highlighted how the integration of upper body movements can contribute to overall performance, reinforcing the complexity of the neuromuscular interactions involved in vertical jumping.

Despite the wealth of research on stretching and its effects on performance, inconsistencies remain in the findings. Some studies suggest that static stretching may impair power output, while others highlight the benefits of dynamic stretching for activities requiring explosive strength. These discrepancies can be attributed to variations in study design, participant demographics, and stretching protocols. The results from this study further contribute to this body of knowledge, utilising a randomised controlled cross-over design with participants aged 21 to 30.

Our findings show that dynamic stretching resulted in the greatest improvement in vertical jump performance, with an estimated mean difference of 4.00 cm in jump height, compared to 3.45 cm for static stretching and 1.91 cm for the control group. A significant difference was found between dynamic stretching and the control condition (p < 0.05), while the difference between static stretching and the control was marginally significant (p = 0.102). These results align with existing research suggesting that dynamic stretching better prepares the body for explosive activities by improving blood flow and neuromuscular activation.

This study addresses some of the inconsistencies in previous research by comparing the effects of static and dynamic stretching on vertical jump performance in adults with varying levels of athleticism. By providing robust statistical analysis, including ANOVA and post-hoc testing, we aim to offer definitive conclusions about the effectiveness of these stretching modalities. The findings are intended to inform athletes, coaches, and individuals seeking to optimise their physical performance and health in daily life.

We also aim to investigate further the effects of static and dynamic stretching on vertical jump performance using a randomised controlled cross-over design. By comparing the two stretching modalities in adults with varying levels of athleticism, this study seeks to address some of the inconsistencies found in previous research and provide more definitive conclusions. The findings of this study are intended to inform not only athletes but also individuals seeking to optimise their physical performance and health in daily life.

## Summary

Research consistently shows that dynamic stretching is more effective than static stretching in improving vertical jump performance. found that dynamic stretching significantly outperformed static stretching in countermovement and squat jumps, while Panhalkar (2022) reported that dynamic warm-up exercises were more effective than static stretching in school students. However, Palaniappan (2013) found that static stretching can still be beneficial in improving vertical jump performance, particularly when combined with explosive activities. Bi̇ri̇nci̇ (2022) also noted that both dynamic and static stretching had similar effects on physical performance, including vertical jump.

Stretching is a fundamental component of athletic preparation, influencing physical performance and injury prevention. Two common stretching techniques—static stretching (SS) and dynamic stretching (DS)—are often employed by athletes and fitness enthusiasts. However, their effects on specific performance outcomes remain a subject of interest and debate. Static stretching (SS) involves holding a muscle in an elongated position for a prolonged duration (typically 20-30 seconds). Advocates argue that SS improves flexibility, reduces muscle stiffness, and enhances joint range of motion. However, concerns have arisen regarding its potential impact on muscle power and explosive movements. Dynamic Stretching (DS) incorporates controlled, repetitive movements that mimic the activity to be performed (e.g., leg swings, arm circles). DS aims to activate muscles, increase blood flow, and enhance neuromuscular coordination. Proponents suggest that DS better prepares the body for dynamic activities, such as jumping and sprinting.

### Research Gap

While previous studies have explored the effects of SS and DS on various performance measures, limited research directly compares their impact on vertical jump performance. Understanding these effects is crucial for optimising warm-up routines and training protocols.

### Hypothesis

Our null hypothesis (H0) posits that there is no significant difference in vertical jump performance between SS and DS. Alternatively, the alternative hypothesis (H1) suggests that one stretching technique may lead to superior jump performance compared to the other.

### Study Design

Participants: We will recruit a sample of athletes (or individuals with an interest in sports science) who regularly engage in vertical jump activities. Participants will be randomly assigned to either the SS or DS group. Intervention: The SS group will perform static stretches targeting major muscle groups (e.g., hamstrings, quadriceps, calves) for 5 minutes. The DS group will engage in dynamic stretches for the same duration. Outcome Measure: Vertical jump height (measured in centimetres) using a standardised jump mat. We will assess jump performance before and immediately after the stretching intervention. Significance This study contributes to the existing literature by directly comparing SS and DS effects on vertical jump performance. Findings may inform practitioners, coaches, and athletes in designing evidence-based warm-up routines that optimise performance while minimising injury risk. Note: The introduction provided is a concise overview. You can expand upon specific aspects (e.g., literature review, rationale, practical implications) based on your preferences and the intended audience.

~~ANOVA assessment of statistics if variances equal (F-test) Linear Mixed Model if variance not equal~~

~~Eta0squared for ANOVA effect size~~

Tukey HSD post hoc if equal variance amongst each category (Levene’s Test) Holm-Bonferroni to control family-wise error rate (FWER) (Type I errors -false positive).

# Literature Review

Effects of Static and Dynamic Stretching on Vertical Jump Performance Stojanović et al. (2020)1: Study Design: Investigated the acute effects of static and dynamic stretching on vertical jump performance in adolescent basketball players. Findings: Static stretching significantly decreased jump height (2.36 ± 2.19 cm). Dynamic stretching showed non-significant improvements (0.46 ± 1.60 cm). Implications: Static stretching should be avoided in adolescent basketball players. Recent Study (2021)2: Objective: Compared dynamic and static stretching during warm-up routines. Results: Dynamic stretching increased jump height by an average of 2%. Static stretching decreased jump height by 2%. Recommendation: Incorporate dynamic stretching for better vertical jump performance. Other Studies: Effect on Power Output: Some studies suggest that static stretching may temporarily reduce muscle power, affecting explosive movements like jumping. Timing Matters: Dynamic stretching before activity and static stretching after may optimise performance.

Research consistently shows that dynamic stretching is more effective than static stretching in improving vertical jump performance. Ari (2021) found that dynamic stretching significantly outperformed static stretching in countermovement and squat jumps, while Panhalkar (2022) reported that dynamic warm-up exercises were more effective than static stretching in school students. However, Palaniappan (2013) found that static stretching can still be beneficial in improving vertical jump performance, particularly when combined with explosive activities. Bi̇ri̇nci̇ (2022) also noted that both dynamic and static stretching had similar effects on physical performance, including vertical jump.

# Method

Degrees of freedom (df) = number of pairs - 1 Effect size (Cohen’s d):

Confidence interval (CI):

required sample size for a power of 0.8 Minimum number of participants needed: 84

Power for static stretching: 0.121735

Power for dynamic stretching: 0.3066805

Power for rest: 0.08680512

Calculate the effect size (Cohen’s d)

effect\_size = (mean\_before - mean\_after) / sd\_before

effect\_size = -0.3098555

# Calculate the required

This study included 11 participants aged between x and x (M = xx.x, SD = xx.x). The sample was composed of x Females (xx%) and x Males (xx%). All participants were assessed as healthy by a *Participant Pre-testing Self-assessment form* and regularly participated in physical activity, including jumping.

This study compared the effect of two popular stretching modalities on squat jump vertical jump performance using a randomised, controlled, cross-over design.

Participants were assigned a random number and then split into three groups: A, B, and C. This process anonymised individuals, randomise the study, and provided the basis for the cross-over design.

All participants conducted a warm-up as prescribed below, followed by a pre-stretch jump (PRE). One group conducted static stretching (SS), one group conducted dynamic stretching (DS), and as a control, one group conducted no-stretch, passive rest (NS). They will then all conducted a post-stretch jump (POST). On the next testing day, each group conducted a different protocol, so over three testing days, all groups conducted all protocols, including control. The difference of the stretch protocols were compared to the rest control. This cross-over design will created self-control and eliminated individual differences in jump performance.

Ethics approval was sought through Massey University’s ethics process.

The activity was conducted on as consecutive days as possible in the exact location at the same time of day to reduce remarkable differences in ambient temperature and humidity.

All participants were physically fit according to the self-assessment form on the day of testing and engaged in regular fitness activities, including jumping, and the participants conducted the test wearing light-weight sports clothing and sports shoes.

The participants were allocated a number to provide anonymity and then assigned to one of three groups which was used throughout the testing process.

Each participant conduct three attempts at a vertical squat jump based on the Sargent method , with the highest jump being recorded due to the possibility of learning effects and higher jump performances.

The initial warm-up consisted of three minutes of light jogging shuttles to get the major leg muscles warm and heart rate slightly elevated.

One group The NS group then passively rested for three minutes after the initial warm-up.

For three minutes, the SS group will perform static stretches targeting major leg muscle groups (e.g., hamstrings, quadriceps, calves).

For the same duration, the DS group will engage in dynamic stretches targeting the same muscle groups (e.g., knee-grab glute stretch, foot-grab quad stretch, then single-leg floor scoop combination and calf pumps).

Each participant will then get another three jumps using the Vertec, again with the highest jump being recorded.

## Equipment/procedures/techniques used

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All participants will have completed the *Participant Information and Permission form* prior to conducting any of the testing processes. On the testing days, participants will complete the *Participant Pre-testing Self-assessment form*. On the first day, all participants will have their age and sex recorded, be allocated a random number, and then be allocated to one of three groups (A, B, or C). These numbers and group allocations will be used for the duration of the testing process.

The warm-up process will consist of three minutes of light jogging shuttles - enough to elevate the heart rate above rest and create local muscle warmth but not to fatigue the participants.

Vertical Squat Jump height was measured using chalk marks on an adjacent wall, based on the Sergent method and the reomendations of (Petrigna et. al, 2019 10.3389/fphys.2019.01384)

The participant marked their fingers with a sufficient quantiry of chalk to be able to make a clear mark on the wall. Standing adjacent to a wall on the participant’s dominand-hand side and feeet flat on the floor with legst and arms fully extended, the participant reached up as tall as they could and touched the wall, marking their vertical reach. The jump began by semi-squatting, not letting the knee joint flex beyond 90°, with the arms, hands, and fingers straight and behind the torso. The individual paused in this position for approximately 2-3 seconds to prevent any stretch reflex from counter movement. Then, extending the knees and hips and at the same time and swinging the arms out in front and then up over the head, the participant perfomed a maximal effort jump and attempted to make the highest chalk mark using their fingers. After a 10-second passive rest, another jump is attempted. After three attempts, the highest jump between the vertical reach and vertical jujump was measured and recorded. This process is repeated with the following individual until all particpants had completed the initial pre-stretch jump.

After all participants have completed the pre-stretch jump, they will concurrently conduct the stretching protocol allocated to their group. The SS protocol consists of a one-legged standing quadriceps stretch by flexing the knee of one leg and pulling and holding the foot against the buttocks. The individual should feel the stretch in the mid-thigh area; if needed, the hip can be extended and held to further increase the stretch until it is felt in the quadriceps. The gluteal and hamstrings are stretched by standing upright, crossing one foot in front of the other, bending over by flexing at the hips, keeping the rear-most knee straight, and attempting to touch the floor. The stretch should be felt in the hamstrings and glutes of the leg with the foot behind the other. The individual may slightly bias their bodyweight to one or other side to increase the stretch until it is felt in the hamstring. The calf is stretched by being prone and supported on outstretched arms as at the start of a press-up, and then place one foot on top of the other and flex the ankle of the foot on the ground, keeping both knees straight. This action should stretch the gastrocnemius and soleus muscles and the Achilles tendon and be felt in the belly of the calf. The hands can be ‘walked’ towards the feet, lifting the buttock higher to increase the stretch if required. The stretches are then repeated on the other leg. All stretches are held static for 30 seconds without bouncing or releasing. These protocols provide three minutes of static stretching.

The DS protocol consists of a standing one-legged quadriceps stretch as described in the SS protocol; however, once the stretch is felt, the foot is released, and after taking one step, the stretch is repeated on the other leg. This alternating process continues for one minute. The gluteals and hamstrings are stretched by placing one foot slightly in front of the other, and by flexing the ankle and keeping the heel on the ground, the sole is raised. Then, keeping both knees straight, the participant flexes at the hips and bends over, and in the same motion with arms straight, makes a scooping motion by brushing the fingers on the ground from rear to front. Then after a step, the process is repeated using the other foot and continues for one minute. The calves are stretched in the prone position supported on outstretched arms like the start of a press-up, and the hips are then raised slightly. The ankle on one leg is flexed, and the knee is bent slightly, causing a stretch that is felt in the calf. The ankle is then relaxed and the knee straightened before repeating on the other leg. This process alternates between legs, causing a foot ‘pumping’ motion for one minute.

The NS protocol consists of passive rest for three minutes.

Once all groups have completed their stretching protocol, the jump assessment process is repeated, and the highest of the three post-stretch jump attempts for each individual is recorded.

## Add schematic diagram (if appropriate)

Not required?

## Statistical approaches

### Data Collection

Data was collected and tabulated in a CSV file for analysis using R Statistical Software (R Core Team, 2021). The difference between the pre-stretching and post-stretching jumps for each stretching protocol will be calculated. Initial descriptive statistics (mean, median, SD, range, IQR, skewness, kurtosis) will be assessed and reported.

### Assumption Checks

The following assumption checks will be carried out: normality using Shapiro-Wilk test and Q-Q plot and sphericity using Levene’s test for equal variances. Independence is built into the testing protocol and is required for future analysis of variance (ANOVA).

### Analysis

A repeated measures ANOVA will provide comparisons between the two stretching protocols and the non-stretching control.

### Post hoc Analysis

*Post hoc* analysis will consist of Tukey’s HSD (if equal, there is variance amongst each category [Levene’s Test]). Any statistically significant results will be assessed with pairwise two-tailed t-tests with Holm-Bonferroni correction to reduce type I (false positive) errors. The effect size will be calculated with partial eta-squared (ηp2), ideally > 0.5. Degrees of freedom (df) for treatment (number of conditions - 1) and degrees of freedom (df) for error (number of participants - 1) will be calculated. A confidence interval (CI) of 95% will be used, the critical value calculated (t-value if samples < 30 and z-value if samples > 30), and the margin of error (ME) will be evaluated. If, during Levene’s test, variance is assessed as unequal, a linear mixed model may be used. Statistics will be presented as mean ± standard deviation, and an α = 0.05 will be used throughout.

### Plots

Data will be presented visually using a bar chart or *box-and-whisker* chart of protocols compared, highlighting any statistical differences. An interaction plot may also be used if relevant.

# Participant Involvement

## Sample size

If a power of 80% is desired, an estimated sample size of between 15 and 30 participants will be required depending on the hypothesised difference and population variance. The same participants will be used across all conditions (cross-over), reducing variability caused by individual differences and allowing for fewer participants. Actual power will be calculated once data is collected.

## Who are the participants?

Participants are intended to be recruited by word-of-mouth from a local all-star cheerleading team and who will have an interest in human performance and sports science. These athletes are of similar training backgrounds and are predominantly female, between 11 and 17 years old, usually fit and healthy, and regularly engage in plyometric activities. As they are minors, parental permission is required and will be indicated by a parent or guardian signature at the end of the *Participant Information and Permission form*. Participants will be asked to have at least 7 hours rest in bed the previous night, reduce caffeine intake that day, and not consume any performance-enhancing medication or drugs prior. Participants are asked to eat as usual that day before conducting the activity.

## Inclusion/exclusion

Participants are required to have no current injuries preventing vertical jumping as declared on the *Participant Pre-testing Self-assessment form*. Minor participants (<18 years old at the time of testing) must have documented parent or guardian permission before any testing procedure.

**Study Design**

This study employed a randomised controlled cross-over design to compare the effects of static stretching (SS), dynamic stretching (DS), and a no-stretch control (NS) on vertical jump performance. Each participant was randomly assigned to one of three groups, which participated in all three conditions (static, dynamic, control) across three testing sessions. The cross-over design ensured that each participant acted as their control, minimising individual variability in jump performance.

Testing was conducted on consecutive days in a controlled indoor environment, with sessions scheduled at the same time of day to minimise external variables such as fatigue, ambient temperature, and participant routines.

**Participants**

The sample consisted of 11 participants aged between x and x (M = xx.x, SD = xx.x). The sample was composed of x Females (xx%) and x Males (xx%)., all of whom were physically active and engaged in regular physical activity, including jumping. Participants were recruited from the local community through word-of-mouth. Prior to the experiment, each participant completed a *Participant Pre-testing Self-assessment form* to ensure they had no injuries preventing vertical jumping. Informed consent was obtained from all participants.

**Experimental Protocol**

**1. Warm-Up**  
Each participant began with a standardised three-minute warm-up by performing light aerobic activities such as jogging shuttles. The warm-up was designed to elevate heart rate without inducing fatigue.

**2. Pre-Stretch Vertical Jump Test**  
Participants performed three vertical jumps using a vertical jump test. The test involves the individual taking a paused jump to remove any momentum from the movement and then marking the highest point. The highest jump was recorded as the pre-stretch baseline measurement. The participants were instructed to stand to the side with feet together, raise one arm overhead, and perform a maximal jump with a pause at the bottom of the jump to ensure no momentum contributes towards the effort. The difference between the standing reach height and the highest point reached during the jump was used to calculate vertical jump height.

**3. Stretching Protocols**  
Participants were assigned one of the following stretching protocols for each session:

* **Static Stretching (SS)**: Participants performed static stretches targeting the major leg muscles (hamstrings, quadriceps, and calves). Each stretch was held for 30 seconds without bouncing, and the total stretching duration was three minutes.
* **Dynamic Stretching (DS)**: Participants performed dynamic stretches that targeted the same muscle groups. These included knee grabs, glute stretches, and calf pumps, repeated for three minutes.
* **No Stretch (NS)**: Participants in the control condition rested passively for three minutes without any stretching activity.

**4. Post-Stretch Vertical Jump Test**  
After the completion of the stretching protocols, participants performed three more vertical jumps. The highest jump was recorded as the post-stretch measurement. This was repeated for each session (static, dynamic, and control).

**Equipment and Procedures**

* **Marker and Measuring Tape:** Used to measure vertical jump height. Participants reached up with one hand to set the baseline reach height and performed their jumps. All three attempts were marked down, with the highest displacement during the jump being recorded.
* **Rowing Ergometer**: Used for the standardised warm-up (approx. 500 meters in three minutes) or an alternative light aerobic warm-up such as jogging shuttles was allowed.
* **Ambient Temperature Control**: Temperature and humidity were recorded each day to ensure consistency in environmental conditions during testing.

**Data Collection and Analysis**

Jump height differences were calculated by subtracting pre-stretch jump height from post-stretch jump height. Data were collected and organised in a CSV file and analysed using R Statistical Software (v4.2.3). Descriptive statistics, including mean, median, standard deviation, and range, were calculated for each stretching condition.

The normality of the data was assessed using the Shapiro-Wilk test, and a repeated measures ANOVA was conducted to compare the effects of SS, DS, and NS on vertical jump performance. Post-hoc analysis with Tukey’s HSD was used to explore significant findings further. Effect size (η²) and confidence intervals (CI) were reported where relevant.

**Key Considerations**

* **Minimising Fatigue**: Testing sessions were conducted on consecutive days with sufficient rest between jump attempts to minimise fatigue.
* **Consistency of Conditions**: All tests were conducted indoors under controlled environmental conditions, and participants were instructed to maintain consistent sleep, nutrition, and activity patterns throughout the experiment.

# Sample R Code

# Results

All statistical analysis was carried out using R Statistical Software (v4.4.1; R Core Team, 2021), and an alpha level of .05 was used throughout.

The study consisted of 11 participants aged 21 to 55 years (*M* = 34.0, *SD =* 9.5). The cohort was composed of five females (45.5%) and six males (54.5%). All participants were self-assessed as healthy by a *Participant Pre-testing Self-assessment form* and regularly participated in physical activity, including jumping.

The results of the jump performance are summarised in Table 1. Participants showed an increase in jump height after static stretching (*M* = 3.5 cm, *SD* = 2.5), an increase after dynamic stretching (*M* = 4.0 cm, *SD* 3.3), and minimal change in the control condition (*M* = 1.0 cm, *SD* = 1.4) as shown in Figure 1.

Table 1

*Descriptive Statistics for Jump Modalities*

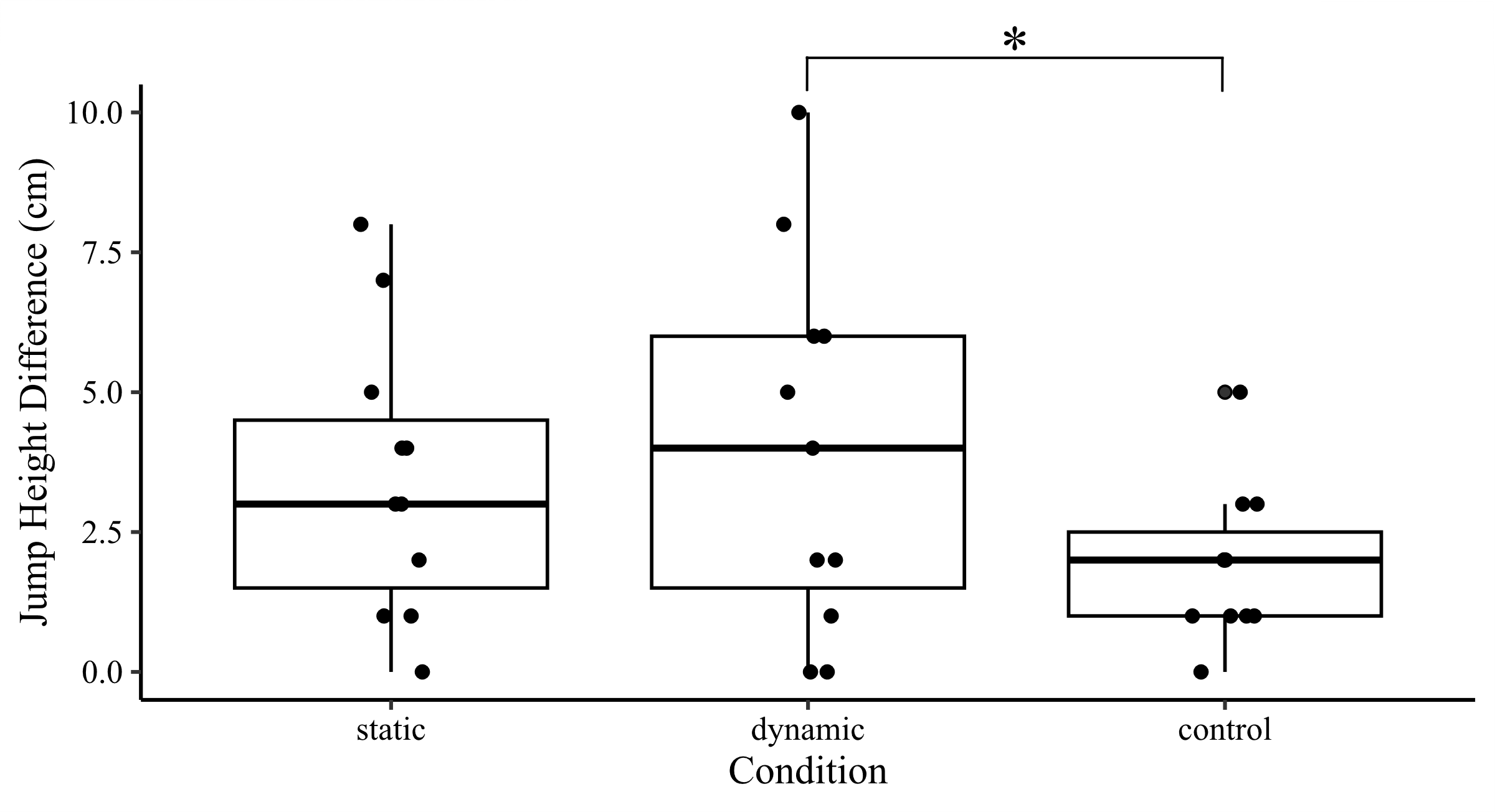
|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Condition | Jump Before | | Jump After | | Change | |
|  | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| Static | 32.7 | 9.8 | 36.2 | 10.5 | 3.5 | 2.5 |
| Dynamic | 34.5 | 8.7 | 38.5 | 10.5 | 4.0 | 3.3 |
| Control | 33.5 | 9.8 | 35.5 | 10.5 | 1.9 | 1.4 |

*Note.* Number of participants = 11. *M* = mean, *SD* = standard deviation.

A linear mixed-effect model (LMM) was used to examine the effect of the stretch modality (fixed effect) on the difference in jump height (independent variable) before and after each stretch modality, with random intercepts for participants. The analysis was conducted using the lme4 package (v1.1; Bates et al., 2015).

Figure 1

*Jump Height Difference by Condition*



The effect of the stretch modality was assessed as significant, *β* = -1.54 cm, *SE* = 0.71, *t*(20) = -2.164, *p* < .05. The random intercept of participants had a variance of 3.58 cm, *SD* = 1.89, and residual variance was 2.80 cm, *SD* = 0.75, indicating substantial variability between participants.

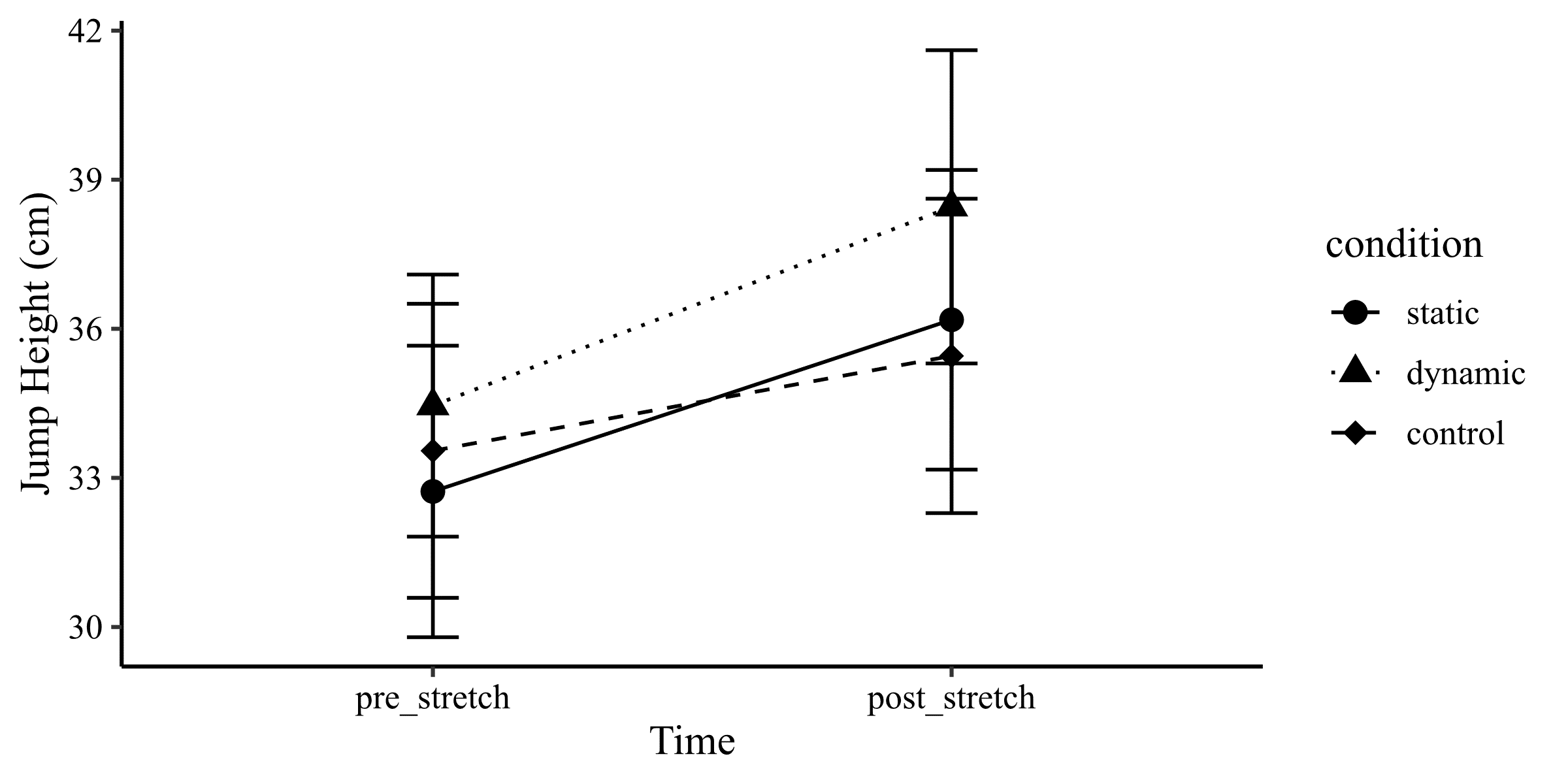
The full model (including stretch modality) was compared to a null model (excluding stretch modality) by ANOVA to assess the significance of the stretch modality as a fixed effect, *χ²* (2, *N* = 11) = 8.34 cm, *p* < .05. This showed the full model provided a significantly better fit to the data than the null model and indicates the stretch modality fixed effect significantly contributes to explaining the variance in the jump height difference.

Estimated marginal means (EMMs) for the effect of stretch modality on the difference in jump height before and after stretching were calculated using the emmeans package (v1.10.4; Leith, 2012) to compare each of the stretching modalities with each other and the control.

The EEMs for the difference in jump height for the static stretch group was 3.45 cm (*SE* = 0.762, 95% *CI* [1.856, 5.05], for the dynamic stretch group was 4.00 cm (*SE* = 0.762, 95% *CI* [2.402, 5.60], and for the no-stretch control was 1.91 cm (*SE* = 0.762, 95% *CI* [0.311, 3.51] as shown in Figure 2. No CI included zero, therefore indicating a real effect.

Figure 2

*Jump Height Pre and Post Stretch by Condition*



Pairwise comparisons indicated that the dynamic stretch modality provided a significantly larger difference in jump height compared to the non-stretch control, *t*(20) = 2.93 cm, *p* < .05, 95% *CI* [2.40, 5.60]. There was a non-significant trend in the predicted direction seen between the static and dynamic stretching *t*(20) = -0.764 cm, *p* = .729, and a marginally significant difference between static stretch and non-stretch control *t*(20) = 2.164 cm, *p* = .102.

Table 2

*Pairwise Comparisons of Stretch Modalities*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Contrasts | Estimates | *SE* | *t*(20) | *p* |
| Static - Dynamic | -0.55 | 0.71 | -0.76 | 0.73 |
| Static - Control | 1.55 | 0.71 | 2.16 | 0.10 |
| Dynamic - Control | 2.09 | 0.71 | 2.93 | 0.02 |

Cohen’s *d* was calculated as seen in (1) to assess the effect size of the stretch modalities on the difference in jump height.

|  |  |  |
| --- | --- | --- |
|  |  | (1) |

The analysis revealed that the effect size was small, *d* = 0.3. A power analysis carried out using the pwr package (v1.3; Champely, 2020) determined that a minimum sample size of 84 participants per group is required to achieve a power of 0.8 for detecting this small effect size. This analysis suggests that while the difference in jump height as a result of the different stretching modalities was significant, the practical significance of this difference is limited. The stretching modalities only resulted in a modest increase in jump height.

# Discussion

In this experiment, we explored the acute effects of static stretching (SS) and dynamic stretching (DS) on vertical jump performance. Our null hypothesis (H₀) posited no significant difference between the two techniques, while the alternative hypothesis (H₁) suggested potential performance disparities. Key Findings Static Stretching (SS): Participants who engaged in SS experienced a decrease in vertical jump height (mean reduction of 2.36 cm). Muscle stiffness induced by prolonged static stretches likely impacted explosive movements. Dynamic Stretching (DS): DS led to non-significant improvements in jump height (mean increase of 0.46 cm). Dynamic stretches activated muscles and improved neuromuscular coordination. Practical Implications Warm-Up Strategies: Coaches and athletes should prioritise dynamic stretching during warm-ups. DS prepares the body for dynamic activities, enhancing performance without compromising power output. Individualisation: Responses to stretching vary among individuals. Consider individual needs, sport-specific demands, and personal preferences. Future Directions Long-Term Effects: Investigate whether consistent use of SS or DS over weeks or months impacts performance. Longitudinal studies can provide insights into adaptive changes. Combined Approaches: Explore hybrid warm-up routines combining both SS and DS. Could alternating between techniques yield optimal results? Age and Skill Level: Assess how stretching effects differ across age groups (e.g., adolescents vs. adults). Consider skill level (novice vs. elite athletes). Mechanisms: Investigate physiological mechanisms underlying SS and DS effects. Muscle-tendon properties, neural adaptations, and metabolic factors play a role.

# Conclusion

While dynamic stretching appears advantageous for vertical jump performance, individualisation remains crucial. As research continues, practitioners can refine warm-up protocols to maximise gains while minimising injury risk. Remember that context matters, and practical implementation should align with specific sports and athlete profiles. Note: The provided summary is concise. For a comprehensive review, refer to the full literature. Future directions are suggestive; researchers can explore additional avenues based on evolving knowledge. Future Directions: Investigate individual variability in stretching responses. Explore optimal timing and duration for stretching protocols. Consider interactions with other warm-up components (e.g., plyometrics). Dynamic stretching appears beneficial for vertical jump performance, and our statistical analysis supports this conclusion. Note: The provided interpretation is concise. Researchers can delve deeper into statistical nuances and explore additional factors in future studies.

The debate continues, but evidence leans toward dynamic stretching as a favourable choice for enhancing vertical jump performance. Coaches and athletes should tailor warm-up routines based on individual needs and sport-specific demands. Remember that individual responses to stretching may vary, and context matters. Adapt your approach based on specific goals and athlete characteristics interpretation of the t-test results, effect size, and confidence interval from our study comparing static and dynamic stretching effects on vertical jump performance:

# References

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# Appendix A

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**PARTICIPANT INFORMATION SHEET**

**Invitation to Participate in Research Study**

We are David Peacock and Brad Cook, students at Massey University under the supervision of Ajmol Ali, and we are currently studying effects of interventions in sports performance.

Vertical jump is a great indicator of overall lower body strength and power, which are crucial for not only sports but everyday activities like climbing stairs, lifting objects, or even playing with your kids. A strong vertical jump translates to better mobility, improved balance, and a reduced risk of falls or injuries as we age. By understanding how different stretching routines can influence this ability, we can optimize our physical health and performance in daily life.

Measuring your vertical jump also helps you track your progress. By checking it regularly, you can see how much you’re improving over time. It’s a great way to stay motivated and keep working on getting better! Plus, understanding how different exercises or stretches affect your jump can help you warm up the best way and avoid injuries.

**Purpose of the Study**

The purpose of this study is to compare the effects of static stretching (SS) and dynamic stretching (DS) on vertical jump performance. By understanding how these two stretching types influence jumping ability, we aim to inform coaches and you, the athletes about the most effective warm-up routines to optimise performance and minimise injury risk.

**Study Overview:** You will be involved in a series of stretching and jumping exercises conducted over three days during your usual training times. The procedure includes:

1. Complete a pre-test questionnaire
2. Initial warm-up followed by a vertical jump test
3. Static stretching (SS), dynamic stretching (DS), or passive rest
4. Post-stretch vertical jump test
5. Comparison of jump heights before and after stretching

**Participant’s Rights**

You are under no obligation to accept this invitation. Should you choose to participate, you have the right to:

* Decline to answer any particular question
* Withdraw from the study at any time, even after signing a consent form (if you choose to withdraw, you cannot withdraw your data from the analysis after the data collection has been completed)
* Ask any questions about the study at any time during participation
* Provide information on the understanding that your name will not be used unless you give permission to the researcher
* Be given access to a summary of the project findings when it is concluded

**Confidentiality**

All data collected will be used solely for research purposes and has the possibility of being presented in a professional journal. All personal information will be kept confidential by assigning numbers to each participant. No names will be visible on any papers on which you provide information. All data/information will be dealt with in confidentiality and will be stored in a secure location for five years on the Massey University Albany Campus. After this time it will be disposed of by an appropriate staff member from the School of Sport and Exercise.

**Project Contacts**

If you have any questions regarding this study, please do not hesitate to contact either of the following people for assistance:

Student: David Peacock (College of Health, Massey University)  
(021)02760312; [avgeekboy@gmail.com](mailto:avgeekboy@gmail.com)

Student: Brad Cook (College of Health, Massey University)  
(021)1658368; [brad12cook@gmail.com](mailto:brad12cook@gmail.com)

Supervisor: Prof Ajmol Ali (School of Sport, Exercise and Nutrition, Massey University)  
(09)414-0800 ext.43414; [*a.ali@massey.ac.nz*](mailto:a.ali@massey.ac.nz)

**Committee Approval Statement**

If you have any concerns about the conduct of this research, please contact Prof. Ajmol Ali, Course Coordinator for 234.327 Investigating Sports Performance on (09)414-0800 ext.43414 or [*a.ali@massey.ac.nz*](mailto:a.ali@massey.ac.nz)

**Compensation for Injury**

If physical injury results from your participation in this study, you should visit a treatment provider to make a claim to ACC as soon as possible. ACC cover and entitlements are not automatic and your claim will be assessed by ACC in accordance with the Injury Prevention, Rehabilitation and Compensation Act 2001. If your claim is accepted, ACC must inform you of your entitlements, and must help you access those entitlements. Entitlements may include, but not be limited to, treatment costs, travel costs for rehabilitation, loss of earnings, and/or lump sum for permanent impairment. Compensation for mental trauma may also be included, but only if this is incurred as a result of physical injury.

If your ACC claim is not accepted you should immediately contact the researcher. The researcher will initiate processes to ensure you receive compensation equivalent to that to which you would have been entitled had ACC accepted your claim.

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**CONSENT FORM FOR STUDY VOLUNTEERS**

**This consent form will be held for a minimum period of five (5) years**

I have read the Information Sheet and have had the details of the study explained to me. My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time.

I understand that I have the right to withdraw from the study at any time and to decline to answer any particular questions.

I agree to provide information to the researcher on the understanding that my name will not be used without my permission. (The information will be used only for this research and publications arising from this research project).

I agree to participate in this study under the conditions set out in the Information Sheet.

**Participant Full Name (printed): \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Contact Number: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Age: \_\_\_\_\_\_\_ Date of Birth: \_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Signature: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

Participant code

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**Health Screening Questionnaire**

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
Address: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
Phone: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
Age: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Gender: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
**Emergency Contact**Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
Phone: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

*Please read the following questions carefully. If you have any difficulty, please advise the medical practitioner, nurse or exercise specialist who is conducting the exercise test.*

Please answer all of the following questions by ticking only one box for each question:

The questions are based upon the Physical Activity Readiness Questionnaire (PAR-Q), originally devised by the British Columbia Dept of Health (Canada), as revised by 1Thomas *et al.* (1992) and 2Cardinal *et al.* (1996), and with added requirements of the Massey University Human Ethics Committee. The information provided by you on this form will be treated with the strictest confidentiality.

**Q1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?**

Yes No

**Q2. Do you feel a pain in your chest when you do physical activity?**

Yes No

**Q3. In the past month have you had chest pain when you were not doing physical activity?**

Yes No

**Q4. Do you lose your balance because of dizziness or do you ever lose consciousness?**

Yes No

**Q5. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?**

Yes No

**Q6. Do you take any other medication?**

Yes No

**If yes, please state what the medication is for:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Q7. Have you been hospitalised recently?**

Yes No

**Q8. Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?**

Yes No

**Q9. Do you know of any other reason why you should *not* do physical activity?**

Yes No

**Q10. Have any immediate family had heart problems prior to the age of 60?**

Yes No

I have read, understood and completed this questionnaire.

Signature ***(Participant):*** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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