EFFECT OF PELVIC FLOOR MUSCLES AND DIAPHRAGM ACTIVATION EXERCISES ON VERTICAL JUMP PERFORMANCE IN JUMPING SPORTS: AN EXPERIMENTAL STUDY

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Abstract— **BACKGROUND: Jumping or leaping is a form of locomotion or movement in which an organism propels itself through the air along a ballistic trajectory and vertical jump is a movement that is used in a plethora of sports. Along with anaerobic strength of lower limb musculature, core strength is equally important to jump higher. Deep core muscles provide stability to trunk and trunk stability is one of the important factors while jumping. Diaphragm forms the roof of the core while the pelvic floor (PFM) forms the base of core. Several studies have examined the impact of core muscle training on performance outcomes with minimal success and few conclusions but there is very limited literature available which evaluates effect of deep core activation on jumping performance.**

Methodology: The design was a pre-post experimental study. A total of 35 female athletes (with mean age 19.2 ± 5.8) related to jumping sports were randomly recruited for this study. Initially vertical jump was assessed using *My Jump lab 3 App*. Participants received pelvic floor muscle activation protocol for 6 weeks and diaphragm activation protocol for 4 weeks. After 6 weeks post-intervention measurements were recorded.

Result: Our study has seen improvement in vertical jump which was recorded pre- and post- intervention in the selected female players in jumping sports. The statistical analysis was conducted at a 95% confidence level, with the t value-16.33 and $p<0.0001$ (<0.05) which is considered statistically significant.

Conclusion: This study suggests that 6 weeks of pelvic floor and diaphragm activation exercises are beneficial in improving jump performance in athletes. Therefore, it seems advantageous to add pelvic floor and diaphragm exercises to the regular training program for athletes to improve their performance

Index terms: Jumping sports, Pelvic floor muscles, Diaphragm, Deep core muscles, Jump

I. INTRODUCTION

Jumping or leaping is a form of locomotion or movement in which an organism propels itself through the air along a ballistic trajectory. Jumping can be distinguished from running, galloping and other gaits where the entire body is temporarily airborne, by the relatively long duration of the aerial phase and high angle of initial launch.

Muscles do physical work, adding kinetic energy to the jumper's body over the course of a jump's propulsive phase. This results in a kinetic energy at launch that is proportional to the square of the jumper's speed. The more work the muscles do, the greater the launch velocity and thus the greater the acceleration and the shorter the time interval of the jump's propulsive phase. Mechanical power (work per unit time) and the distance over which that power is applied (e.g. leg length) are the key determinants of jump distance and height.

A vertical jump is a movement that is used in a plethora of sports [1]. The action of jumping is central to several sports and activities. Some sports are based almost exclusively on the ability to jump, such as high jump in track and field, whereas in other sports the act of jumping is one of multiple athletic abilities used in the sport, such as basketball. There is also evidence that vertical jumping ability is an essential element in the performance of several fundamental skills in various team sports such as football (soccer), volleyball, basketball, and handball. [2]

The vertical jump uses the muscles in your lower body, including the quadriceps, hamstrings, gluteal muscles and calves. It also recruits the muscles in your core and upper body for power and stabilization.

Along with anaerobic strength of lower limb musculature, core strength is equally important to jump higher. The core is the centre of the functional kinetic chain providing the proximal stability for the distal mobility and function of the limbs [3]. The core district strength is an important prerequisite for the practice of many sports, such as football, basketball, athletics jumping disciplines and others, and to carry out some everyday activities such as walking, climbing stairs, keep posture upright [4] Core muscles provide stability to trunk and trunk stability is one of the important factors while jumping. Akuthota and Nadler defined core strength as the involvement of the anatomical structures around the lumbar spine in the maintenance of functional stability [5] the core muscles are important for dynamic stabilization. The core stability is essential to prevent injuries and improve performance in athletes. Weak core muscles may be a risk factor for low back pain. It has been reported that core muscle fatigue decreased dynamic stability of the trunk and loss of balance control. Dynamic balance is defined as the ability of an individual to maintain stability of the center of mass during movement and an essential component of many sports activities. Also, it is an important factor associated with lower extremity injury and performance in athletes. [6]

The core musculature includes muscles of the trunk and pelvis that are responsible for maintaining the stability of the spine and pelvis and are critical for the transfer of energy from larger torso to smaller extremities during many sports activities. Therefore,

it is theoretically believed that if the extremities are strong and the core is weak the decrease in muscular summation through the core will result in less force production and inefficient movement patterns.[7].

Many different models of the core anatomy have been proposed in the literature. The abdominal muscles, consisting of the transversus abdominis, rectus abdominis, and internal and external obliques, are primarily involved in controlling the position of the spine and pelvis. The transversus abdominis increases intra-abdominal pressure and tensions the thoracolumbar fascia while the abdominals collectively contract to create a rigid cylinder to stabilize the spine. It is the thoracolumbar fascia that connects the upper and lower extremities in order to integrate the superior/inferior and right/left parts of the kinetic chain. The thoracolumbar fascia is also connected to the internal obliques and transversus abdominis and functions to provide further cylindrical stabilization to the spine. The diaphragm also has been shown to assist with spinal stability by contracting prior to limb movement and independent of respiration.[7]. The hip and pelvic floor musculature serves as the base of support for the core. According to Hodges, synergistic activation patterns exist in pelvic and trunk controlling musculature [7].

The core muscles can be divided into two groups, stabilizers and global movers. The stabilizer muscles include: Pelvic floor, Transversus abdominis, Internal Obliques, Multifidus, Diaphragm Some literature also includes the deep fibers of the psoas and the deep hip rotators as part of the inner core. The global movers/muscles include: Rectus abdominis, External obliques, Erector spinae, Quadratus lumborum, Hip muscle groups.

Pelvic floor muscles (PFM) are located at base of your of pelvis. The pelvic floor refers to a group of muscles that support the organs in the pelvis. This is composed of the pelvic diaphragm, which extends from the symphysis pubis anteriorly to the coccyx posteriorly, forming a hammock-like structure which supports abdominal cavity. Thus, pelvic floor is one of the important muscles to provide stability. The pelvic floor muscles are composed of levator ani muscles including puborectalis, pubococcygeus and iliococcygeus muscles, and coccygeus muscles [8]. The pelvic floor muscles are organized into superficial and deep muscle layers. The superficial muscle layer and the muscles relevant to the anal canal function are the external anal sphincter, perineal body and possibly the puboperineal (or transverse perinei) muscles. The deep pelvic floor muscles consist of pubococcygeus, ileococcygeuys, coccygeus and puborectalis muscles. In fact, puborectalis muscle is located in between the superficial and deep muscle layers, and it is better to view this as the middle muscle layer of the pelvic floor [9]

The “gold standards” for vertical jump height measurement are video analysis to calculate the position of the body’s centre of mass and integration of the ground reaction force measured on a force plate. However, relative to “real-world” assessment by non-elite and/or non- research populations, limited access to laboratory settings, excessive cost of such measurement tools, time, and/or expertise constraints render these approaches largely unsuitable for field assessments conducted by many sport and physical activity practitioners. One of the common measuring tools used for the assessment of VJ in the field is the Vertec. Though the use of vertec to measure VJ height is common due to convenience and price point, it requires execution of a more complex jump from the participant [10].

A new approach to vertical jump height measurement is the use of mobile applications. The relative ease of use, affordability, and portability makes My Jump an attractive option for non-elite and/or non-professional movement practitioners. My Jump, a mobile application for iOS and android devices, uses the device camera’s frame-by-frame analysis to calculate flight time and jump height. Furthermore, the is excellent agreement between force plate and My Jump measurements. However, both the force plate and My Jump use flight time as the source of the height calculation. High reliability and accuracy of My Jump compared to the gold standard (force plate) has been reported. Also, My Jump compared to Vertec demonstrated good to excellent reliability relative to degree of consistency [11,12].

II. NEED OF STUDY

The impact of high-intensity sporting activities on perineal structures, coping with intra- abdominal pressure increases up to 16 times body weight, poses a critical need for study. Young female athletes, especially during activities like running and jumping, undergo sudden and significant intra-abdominal pressure spikes. Pelvic floor muscles (PFM) play a key role in balancing these pressures, exhibiting pre-activity and reflex responses during vertical jumps (13). Beyond their role in athletic endeavours, PFMs are integral to trunk stability, essential for functional activities. Collaborating with the diaphragm and abdominal muscles, PFMs don't act independently but respond to changes in intra-abdominal pressure systematically. Studies have also found that there is no significant difference between the strength of the pelvic floor muscles in athletes and untrained women. It indicates that the pelvic floor muscles are not strengthened in parallel with comprehensive training, but require special exercise [14]. Also, the Pelvic Floor Muscles (PFM) undergoes fatigue due to high repetition of running and jumping activities which results in decreased blood flow to the muscle fibres with depletion of nutrients and oxygen.[15] While studies have shown that jumping stimuli inducing involuntary PFM contraction could show a beneficial factor to be integrated in a PFM rehabilitation program. Also, pelvic adjustments has shown an improvement but pelvic floor rehab activation exercises has never been explored to see an effect direct on the jumping performance.

III. AIM OF STUDY

The aim of this study is to evaluate the effect of pelvic floor muscle activation and diaphragm activation on vertical jump performance in female athletes who play jumping sports.

IV. OBJECTIVES

To find out the effectiveness of pelvic floor muscle activation and diaphragm activation on vertical jump performance in female athletes who play jumping sports over the period of 6 weeks using My Jump Lab 3 App.

V. HYPOTHESIS

- **Null Hypothesis [H0]:** Pelvic floor muscles and diaphragm activation will not be showing significant difference on jump performance over the period of 6 weeks with respect to my jump app.
- **Alternate Hypothesis [H1]**: Pelvic floor muscle and diaphragm activation will be showing significant difference on jump performance over the period of 6 weeks with respect to my jump app.

Methodology

The design was a pre-post experimental study. A total of 35 female athletes (with mean age 19.2 ± 5.8) related to jumping sports were randomly recruited for this study. Initially vertical jump was assessed using My Jump lab 3 App. Participants received pelvic floor muscle activation protocol for 6 weeks and diaphragm activation protocol for 4 weeks. After 6 weeks post-intervention measurements were recorded.

Eligibility Criteria: Studies that were selected for further critical appraisal met the following criteria

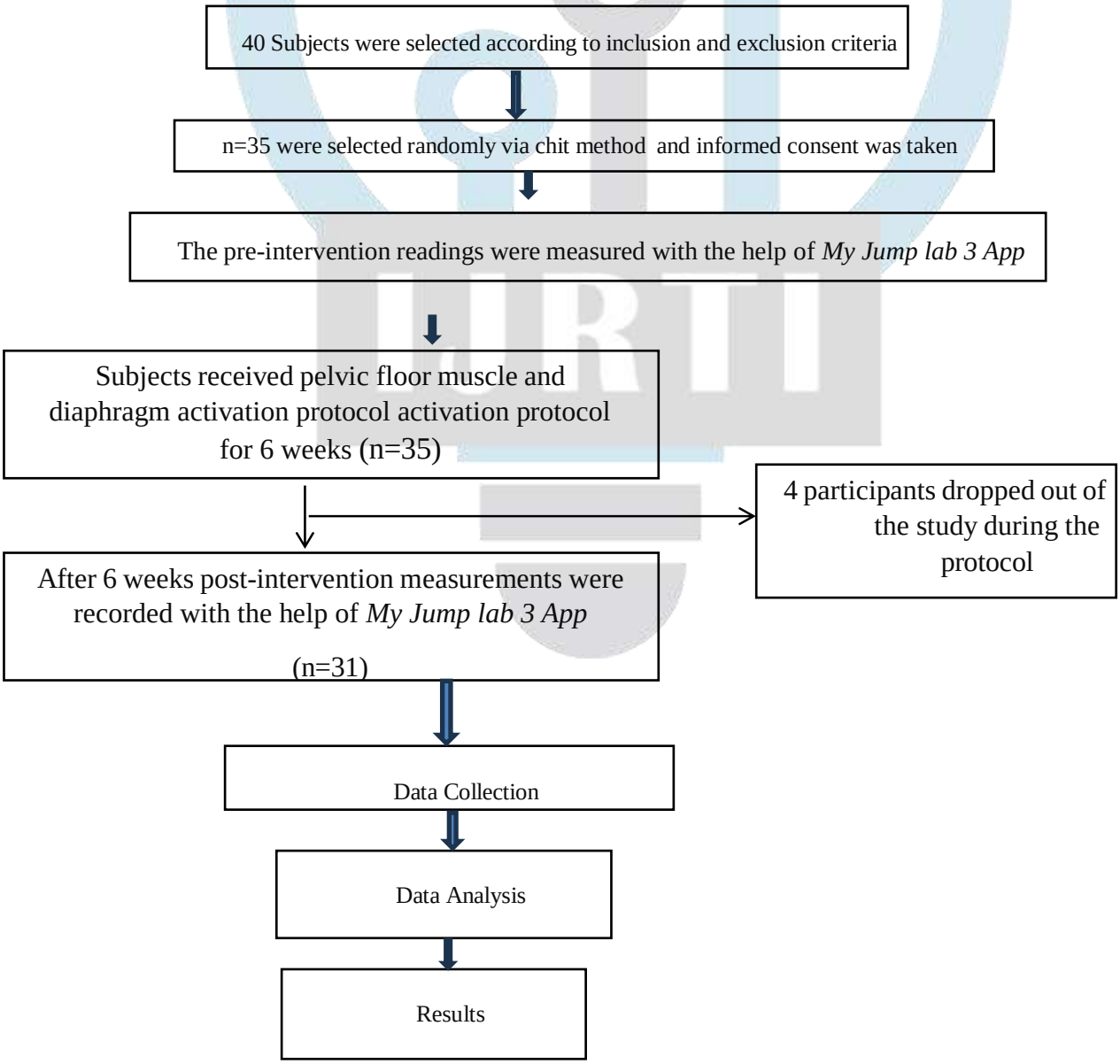
Inclusion Criteria:

1. Female athletes in jumping sports who are willing to participate.
2. Playing jumping sports since at least 2 years.
3. Age 15 -24 years
4. Athletes who have started menstruating

Exclusion Criteria:

1. History of repetitive Urinary Tract Infection
2. BMI <18 kg/m2 or >25 kg/m2
3. History of pelvic pathology
4. Any lower limb injuries.
5. Athletes with limb length discrepancy
6. Athletes with respiratory disorders
7. Athletes who practice breathing exercises.

Figure 1: Flow diagram



VI. PROTOCOL

Total 35 subjects were included according to the inclusion criteria via random sampling method and informed consent was taken. The treatment protocol was explained to the subjects. After that, the pre-intervention readings were measured by using My Jump lab3 App. This data was measured on the 1st day (baseline) before the initiation strengthening protocol. After taking the pre-intervention reading, the strengthening protocol was administered through a specific procedure. Each participant performed 20 sets of PFME exercises twice a day, 5 days per week for 6 weeks and diaphragm training for 12 sessions over the period of 6 weeks. Participants performed two exercises per week for 5 min twice daily, for total of 20 min per day at least 5 days per week.

Pelvic floor muscle exercise (PFME) protocol: One set of PFME consists of 1 slow contraction followed by 1 fast contraction. In which, 1 slow contraction is contracting the perivaginal and perianal muscles by holding a strong contraction for 10 second and 1 fast contraction is briefly contracting and relaxing the muscles rapidly for a total of 10 times.

Diaphragm training protocol:

First week: Supine breathing + Crocodile breathing

Second week: Supine breathing with TheraBand + Crocodile breathing with TheraBand

Third week: Seated breathing + 90/90/90 breathing

Fourth week: Seated breathing with TheraBand + 90/ 90/90 breathing with TheraBand

Each participant was provided with a handbook which contains detailed information regarding structure of pelvic floor, function of pelvic floor, location and function of diaphragm and detailed instructions about PFME.

The post-intervention readings were measured after 6 weeks with the help of *My Jump lab 3 App*. n=31 for post protocol readings, as 4 participants dropped out of the study.

VII. RESULT

Our study has seen improvement in vertical jump which was recorded pre- and post- intervention in the selected female players in jumping sports. The statistical analysis was conducted at a 95% confidence level, and $p<0.05$ is considered statistically significant. In our study, a significant intervention effect was observed with a p-value of less than 0.00001, indicating strong evidence against the null hypothesis. The pre-test mean value was 19.98 with a standard deviation of 5.786, while after the intervention, the mean increased to 25.78 with a standard deviation of 6.583. This yielded a mean difference of 5.8 CENTIMETERS. The t-value calculated was 16.33, based on a sample size corresponding to 29 degrees of freedom. These findings suggest a substantial and statistically significant impact of the intervention, indicating a notable improvement in the measured outcome.

VIII. DISCUSSION

The present study was undertaken with the intention to see the effect of pelvic floor muscles and diaphragm activation on vertical jump performance in jumping sports. The result of present study shows that the intervention is effective in improving jump performance in athletes playing jumping sports.

A total of 45 samples were selected according to inclusion criteria out of which 35 participants were randomly drawn by chit method and included in study. 4 participants dropped out of the study during the protocol. One participant withdrew from the study due to an ankle injury, another due to academic examinations, and two others for personal reasons. Thus, total of 31 female athletes who play jumping sports aged 10–24 years were included in the study. The pre-test and post-test were recorded using my jump lab 3 application to assess the vertical jump height.

The statistical analysis of pre and post-test readings of jump height showed a significant improvement in range ($p<0.05$) and a mean difference of 5.8 cm following the exercise protocol for activation of pelvic floor muscles and diaphragm, indicating a significant improvement in jump performance. Our study results are consistent with previous research on the impact of core stability, pelvic floor activation exercises, and diaphragm training on vertical jump performance in athletes. This consistency enhances credibility of our findings and indicates that pelvic floor and diaphragm activation exercises may improve jump performance in athletes. By aligning with other studies, our research strengthens the growing evidence that pelvic floor and diaphragm activation is beneficial in sports contexts.

However, certain limitations restrict the broad applicability of the study's findings. The study emphasizes on participants aged 15–24 limits the ability to generalize the results to other populations. The relatively small sample size (31 participants) raises concerns about statistical power and the potential for biases. The short intervention duration may not capture long-term benefits as no follow-up assessments were conducted post-intervention in this study. However, differing results could manifest if the range were evaluated following a follow-up period. The observed benefits suggest the possibility of even greater improvements in jump performance with continued and consistent practice of strengthening protocol.

My Jump lab 3 app has been used as an outcome measure. Previous studies have reported its reliability to be moderate to excellent with ICC value-0.813. However, during our study we observed that the app requires video which is shot on plain hard surface for analysis, as videos shot on other non-hard surfaces like mat can create rebound effect which hampers the analysis. Future research should encompass a more diverse and extensive participant pool, longer intervention periods. Addressing these issues will yield a more comprehensive understanding of training strategies for players and its practical implications for sports professionals.

IX. CONCLUSION

In conclusion, this study suggests that 6 weeks of pelvic floor and diaphragm activation exercises are beneficial in improving jump performance in athletes. Hence the null hypothesis is rejected. Therefore, it seems advantageous to add pelvic floor and diaphragm exercises to the regular training program for athletes to improve their performance

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