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Effectiveness of Upper Limb Proprioceptive Training on Balance and Strength in Mallakhamb Players

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Abstract:
Background*: Mallakhamb, characterized by its dynamic movements, enthusiasm, and unconventional nature, is said to embody the essence of Hanuman, the Hindu simian deity. Mallakhamb primarily involves poses, emphasizing upper limb usage for holds, catches, and body balancing against gravity, with more weight-bearing in the upper limbs compared to the lower limbs. Upper limb strength and balance are crucial in this sport, as the poses require supporting body weight and transitioning between positions on extremities against gravity efficiently.*
Materials and Methods*: A total of 25 mallakhamb players with age range of 12 to 18 years with a mean age of 13.8 (± 1.19) years participated in the study. Subjects were screened as per the inclusion and exclusion criteria. The pre intervention assessment was done using seated medicine ball throw test, handheld dynamometer, handstand test and skill performance hatacha farara. The players were then given an intervention of upper limb proprioceptive training of 4 weeks (3 days /week). Outcome measures were reassessed post intervention. Data obtained was further analysed using SPSS 30.*
Results*: From the data obtained through the current study, results showed significant improvement in the upper limb strength, upper limb balance and skill performance (hatacha farara) with upper limb proprioceptive training.*
Conclusion: *The findings of this study support the incorporation of upper limb proprioception exercises along with mallakhamb routine in improving their strength, balance and performance.*
Key Word*: Upper Limb Proprioceptive Training, Mallakhamb Players, Strength, Balance.*

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I. Introduction

An age-old Indian sport, Mallakhamb combines two Sanskrit words: "Malla," denoting a gymnast, and "khamb," signifying a pole. This traditional activity has deep roots in Indian culture.[1] Mallakhamb blends elements of Yoga, Gymnastics, and Martial Arts.[2] Mallakhamb is a traditional Indian sport, with a combination of exercises that demands flexibility, strength, speed, concentration, coordination, and agility.[9]

Subsequently, mallakhamb gained widespread recognition and popularity among Indian youth. The sport has also begun to find acceptance in countries like the United States, Germany, and Japan.[2] The recent establishment of the International Mallakhamb Federation marks another milestone. While mallakhamb encompasses various forms, competitive events primarily feature pole, rope, and hanging mallakhamb.[2]

Badminton, tennis, volleyball, throwball, and other overhead sports are open chain kinetic movements whereas mallakhamb has more of closed kinetic chain movements. These movements are with upper limb in weight bearing position, like handstand, fish planks, bent natrajasana and many more elements therefore it is challenging to attain and hold these poses on a small base of support as it requires good balance and strength training to perform such elements on the pole.[9]

A key aim of shoulder physical training is to enhance muscle strength for joint stability. The stability of the shoulder joint results from both dynamic and static elements. The foundation for both static and dynamic interactions is proprioceptive input from centrally integrated mechanoreceptors in muscles, tendons, joint-capsule ligaments, and skin. In this context, proprioception sub-modalities encompass kinaesthesia, joint position, and force sense.[9]

Proprioception is the body's awareness of position and movement, including perception of body segment static position, displacement, velocity, acceleration, and muscular force and effort.[4] It comprises two

essential aspects: the ability to determine limb position at any given moment and the capacity to adjust muscle contractile forces in response to external forces.[7]

Upper limb strength and balance are crucial in this sport, as the poses require supporting body weight and transitioning between positions on extremities against gravity efficiently. Incorporating upper limb proprioceptive exercises may help mallakhamb players achieve error-free performances. A study revealed that mallakhamb players performance was affected by upper limb and lower limb parameters like balance, strength, power, flexibility and core strength, however player's core strength, upper limb balance and upper limb strength were average and thus the need of study arises to work on these parameters to enhance the mallakhamb players performance.[3]

The aim of the study was to assess the effect of upper limb proprioceptive training on balance, strength and skill performance in upper extremity of mallakhamb players. The objective of the study was to find out the effect of upper limb proprioceptive training on upper limb balance, strength and skill performance in mallakhamb players.

II. Material And Methods

This Quasi experimental study was carried out on Mallakhamb players from various academies of Mumbai for one year. A total 25 players of age group 12-18, both genders were taken for the study

Study Design: Quasi experimental study with pre-test and post-test study design

Study Setting: Mallakhamb academies, Mumbai

Study Duration: 1 year.

Sample size: 25 Mallakhamb Players.

Subjects & selection method: The study population included 25 Mallakhamb players selected by convenience sampling from various mallakhamb academies of Mumbai.

Inclusion criteria:

1. Players of age group 12 – 18 years both genders and who have been regularly practicing Mallakhamb for at least one year.

Exclusion criteria:

1. Players who have recent injuries related to the upper extremities and hence unable to participate in the study.

Procedure methodology

5 Mallakhamb academies of Mumbai were approached out of which 2 showed interest. Permission was taken from the head of those academies to carry out the assessment in their setup. Then, subjects were selected based on inclusion and exclusion criteria. Subject were been informed about the study and written informed consent had been taken from their parents after which assessment was done. The selected players were given an intervention of 12 sessions for 4 weeks (3 days/week). The players were allowed to do their regular mallakhamb routines.

a. Outcome Measures

1. Seated Medicine Ball Throw Test (SMBT)

SMBT was used to assess shoulder strength with good reliability inter-examiner (ICC = 0.84) and intra-examiner (ICC = 0.77).[6] The player was asked to be seated on the floor with back supporting against the wall and legs extended and hold a 3 kg medicine ball in hand. The players were asked to throw the ball horizontally on the measuring tape and the distance was recorded with 2 trials.

2. Handheld Dynamometer (HHD)

HHD was used to assess individual hands strength with reliability (ICC = 0.72-0.92). The player was asked to grip the dynamometer with full strength without change in position of the body and hold for 5 sec, 2 trials were given.

3. Handstand Test (HST)

HST was used to assess upper extremity balance with Inter-rater reliability: ICC = 1.00 Construct validity (Test score vs. Competitive level): r 2 = 0.65. [21] The player was told to begin the handstand on a pair of parallel bars that were separated by 1.5 feet. The participant's longest handstand hold was used during the two trials to make up the final score.

4. Hatacha farara

It was used to assess the skill performance of the player. The player mounted on the pole as the first step and then took the entire body into an antigravity position with one hand on the head of the pole and the other hand on the body of the pole balancing the entire body in a straight line. The mallakhamb judge assessed each player's performance based on mallakhamb regulations, which was considered the score for skill performance.

b. Intervention Protocol

Table No 1: Intervention Protocol

Exercises	Week 1	Week 2	Week 3	Week 4
Rhythmic Stabilization	30 sec holds *2	1 min hold*2		
Quadruped	30 sec holds *2	1 min hold*2		
Knee Push up	30 sec holds *2	1 min hold*2	2 mins hold	
Prone on elbows	30 sec holds *2	1 min hold*2	2 mins hold	
Push up		30 sec holds	30 sec hold*2	
Feet Elevated Full Push Up		30 sec holds	30 sec hold*2	30 sec hold*2 (against wall/ handstand)
Hands on Wobble Board			1 min hold	1 mins hold*2 (single leg)
Hands on Bosu ball			1 min hold	2 mins hold (single leg)
Elbows on Swiss ball				1 min hold*2
Hands on Swiss ball				1 min hold*2

Statistical analysis

The data analysis was done using Statistical Package of Social Analysis (SPSS) version 30. Wilcoxon Signed-Rank Test under the two related samples category in the non-parametric group was used to compare the pre intervention and post intervention values. The result was concluded statistically significant with the p value ≤ 0.05 and at confidence level of 95%.

III. Result

Total 25 subjects from various Mallakhamb academies volunteered for the study 12 males and 13 females with a mean age of 13.8 ± 1.19 years and mean experience of 3.48 ± 1.66 years.

Table No 2: Analyses of all outcome measures

Outcome Measures	PRE-INTERVENTION	POST-INTERVENTION	P-Value
Seated Medicine Ball Throw Test (in cm)	208 ± 5.480	235.92 ± 4.879	<0.001
Handstand Test (in points)	1.20 ± 0.129	2.16 ± 0.138	<0.001
Rt Dynamometer (in Kg)	26.92 ± 1.036	31.12 ± 1.168	<0.001
Lt Dynamometer (in Kg)	26.56 ± 0.843	30.32 ± 1.104	<0.001
Skill performance score (in points)	0.512 ± 0.2408	1.524 ± 0.4087	<0.001

On comparing the data from table no 2, there was statistical improvements in the upper limb strength, upper limb balance and skill performance of Mallakhamb players with all the outcome measures pre and post intervention ($p < 0.001$).

IV. Discussion

According to the study, a positive effect of upper limb proprioceptive training on mallakhamb players with respect to their upper limb strength, upper limb balance and skill performance was seen.

1. Upper Limb Strength

Strength of the upper limb was assessed using seated medicine ball throw test and handheld dynamometer. The upper limb proprioceptive exercises like quadruped, knee push up, prone on elbows, prone on hands, feet elevated push up, hands on wobble board, hands on bosu ball, elbows on swiss ball and hands on swiss ball, alter muscle flexibility in addition to joint approximation and activate the sensory receptors – Muscle spindle and Golgi tendon organs.[7, 26] Firstly, the muscle spindles, get activated when there is change in the muscle length. When the muscle fibre shortens, the impulses sent are decreased as there is no lengthening of the muscle fibres. These quick stretches are responded by the muscle with a brief contraction. Secondly, the golgi tendon organs get excited with rise in muscle tension or passive stretching and send signals to nervous system to adjust this muscle tension. The muscles trapezius, serratus anterior, rhomboids, levator scapulae, latissimus dorsi, pectoralis, supraspinatus, infraspinatus, teres major and minor helped to stabilize the scapula. The deltoid, triceps, biceps, brachialis co-contracted to stabilize the shoulder joint. Flexor carpi radialis, flexor carpi ulnaris, flexor digitorum superficialis, flexor digitorum profundus and hand intrinsic muscles worked concentrically at the hand and wrist complex. The upper limb proprioceptive exercises acted like closed chain kinetic exercises with greater motor unit firing in synchronization at multiple joints. The muscles were in a brief contraction of 30 sec that progresses up to 1-2 mins for 2 repetitions with the body weight as a resistance to the isometric force generated. This contributed to strengthen the upper limb muscles through the intervention of upper limb proprioceptive exercises.[14, 23, 26]

A study done in 2022 by Diana Victoria Gidu et al. on teenage soccer players using a Proprioceptive Training program showed favourable findings consistent with this study for explosive strength via repetitive loading on the joint with the body weight and increasing the isometric forces of the muscles. Another research aligning with this study showed significant difference in the development of strength in the muscles around the joint with increased dynamic stability performed on women soccer players with 15 mins of lower limb proprioceptive training before the training session. Though these study with proprioceptive training were conducted on lower limb, the same physiological rationale can be considered for the improvement in the upper limb muscle strength as well.[16, 28]

The results of present study also line up with Gidu, D.V et al., on 10 weightlifters with pain and history of shoulder injuries using proprioceptive training programme of 15 minutes time duration, two times per week, for a period of 20 weeks, suggesting repetitive muscular forces are generated during the exercise performance that help to improve the muscular strength.[8] Likewise a study by V. Gabriela on fencers, showed positive results in agreement to this study and credited the results to improvement in ankle muscle strength with 12 week lower limb proprioceptive training, due to good dynamic ankle stability.[29] Thus, the improvement in muscle strength can be attributed to both isometric contractions, and co contractions, and alternating muscular forces resulting during proprioceptive training.

2. Upper Limb Balance

It was assessed using handstand test. Balancing is important in mallakhamb players as they have several elements in which the body is in a straight line either parallel or perpendicular to the pole with body weight on the arms and hand. During the upper limb proprioceptive exercises, players were instructed to maintain their upper limb balance on firm ground and progressed gradually towards hands on wobble boards, hands on bosu ball, and elbows on swiss ball to hands on swiss ball for maximum 1 min hold for 2 repetitions. The proprioceptive reflex helps to maintain the body's centre of mass in a neutral position. The upper limb proprioceptive training helped to improve the efficacy of the afferent feedback, to attain functional upper limb control and to achieve appropriate neuromuscular access to the muscles surrounding joint complexes. This training also challenges the vestibular system to further progress and balance a body on unstable surfaces like bosu ball and swiss ball to improve the proprioceptive and dynamic stability of the upper limb by contracting the muscles around the upper limb joints. There was co-contraction of the shoulder muscles, scapular stabilizers and concentric contraction of the hand and wrist complex muscles. These exercises challenged the motor pathway with various changing unstable surfaces to promote the joint stability, ultimately helping the body to maintain its balance. [14, 23, 26,27,28]

A study by Ambarish Akre and colleagues used a comparison of the strengthening and proprioceptive training programme of 4 weeks on chronic ankle instability individuals, showed significant improvement in dynamic balance of both groups due to increased joint stability, therefore this contributes towards the present study.[17]Another study conducted by Sihyun Yoo et al. revealed that proprioception training and lower-extremity muscle strength training both enhanced athletic performance and improve the ability of athletes to maintain the Taekwondo crane stance, the proprioceptive exercises increase the muscular strength, this strength helps to control and hold a posture via joint stability to improve balance.[18] Thus these findings support this study, as the muscular strength grows the joint stability also improves leading to improvement in the balance. Another study by M G Bedydagi on the professional football athletes showed significant improvement in static balance of the player with 6 week lower limb proprioceptive protocol by activation of vestibular system challenges and neuromuscular control. [31] Though these studies were done in lower limb it can be used for the current study.

3. Skill Performance

The Mallakhamb element Hatacha farara was used to assess skill performance. As seen in the current study upper limb proprioceptive exercises increase the muscular strength due to brief contraction of 1-2 mins with greater motor unit firing in the muscles at various joints helps to attain the haracha farara. The shoulder complex, elbow, hand and wrist joints went in close approximation to stimulate the mechanoreceptors in muscles and around the joint line to enhance sensory input for the control of the movement. The muscles rotator cuff, rhomboids, trapezius, serratus anterior helped to stabilize the scapula. There was co-contraction of deltoid, triceps, biceps, pectoralis, brachialis, brachioradialis, at the shoulder and elbow joint. Flexor digitorum superficialis and profundus, flexor carpi ulnaris and radialis and intrinsic hand muscles worked concentrically at forearm, wrist and hand. The upper limb proprioceptive training helped to 'teach' the agonist and antagonist muscles to stabilize a joint complex actively.[14, 23, 26, 27] The change of surfaces from firm ground to wobble board, bosu ball and swiss ball challenges the motor pathway. This challenge helped to increase the joint stability at shoulder, elbow, wrist and hand complexes. When a body gets adapted to these various surfaces it helped to prepare the muscles to work in similar scenario, thus the upper limb proprioceptive exercises educated

the body to balance on unstable surfaces making it easier for the body to balance on a steady vertical pole which had small base of support to balance. It may help to reduce the risk of injury.

The findings of this study are consistent with a systematic review of 19 studies with the proprioceptive training on athletic performance on 621 participants of various sports disciplines showed that proprioceptive training improved athletes' technical skills along with physical performance in various disciplines like passing technique, shooting technique, dribbling skills. This was attributed by the improvement in muscle strength, and postural balance, however the joint stability was not evaluated in this study. It further mentioned that proprioceptive training helps to reduce the injury rates.[19]

Another study with similar findings was done by Sanja Šimek Šalaj et al., on active men with proprioceptive exercises for 10 weeks showed statistically significant improvement in the skill performance. This was due to the increase in strength of leg extensor muscles along with the inhibition of stretch reflex and the co-contraction mechanism. N. Baral studied the impact of proprioceptive training on fear of re-injury and functional performance on athletes with ankle sprains which showed positive results in agreement to this study and attributed the results to improved muscle coordination along with muscle endurance and influence on neuromuscular functioning and instability, thus improving balance and normalizing joint position sense. [30]

V. Conclusion

The present study concludes that incorporation of upper limb proprioception exercises along with mallakhamb routine would thereby help the players in improving their strength, balance and performance. Use of upper limb proprioceptive exercises may further help to reduce the risk of injury and enhance the performance of the players.

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