

Rehabilitative Balance Exercises Program for Restoring Stability and Performance after Ankle Injuries

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Abstract: This research aims to identify the effectiveness of balance exercises on restoring the stability and functional efficiency of ankle joint. The researcher used the experimental approach (two-group design) with pre- and post-measurements. Participants (n=10) were purposefully chosen from soccer players of Al-Qadesia Sports Club – Kuwait. They were divided into two equivalent groups. The experimental group (n=5) contained players with functional disorder and instability of ankle joint (right foot) because of repeated ankle sprain injury. The control group (n=5) included players who were free of any ankle injuries. Results indicated that: - The recommended balance exercises improved stability of the injured ankle joint. - The recommended balance exercises improved function of the injured ankle joint. - The recommended balance exercises fully rehabilitated the injured ankle joint. - The recommended balance exercises improved confidence and decreased fears of lack of stability among injured athletes. - The recommended balance exercises improved proprioceptors function of the injured ankle joint.

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Key Words: Balance Exercises – Stability – Ankle Injuries

1. Introduction:

Ankle joint is a major joint as it plays a major role in performing movements and activities used in daily life, as well as training and competition. It is one of the most joints vulnerable to injury and such injuries may limit movement because of sprains and ruptures.

One of the negative effects of repeated ankle sprain and ligament rupture is the instability of the injured ankle as the injured joint becomes unstable and functionally unbalanced. This leads the joint to lose its normal range of motion and the athlete becomes unable to perform the required skills and movements. Eventually, the athlete stops practicing sport (Christopher et al 2003: 119).

Balance is an indicator of joint stability (Smith et al 2002: 97). Ankle sprains decrease the ability of self-sensory receptors in the injured ankle. The decrease of sensitivity of self-sensory receptors results from damage of micro self-sensory receptors in ligaments, skin and muscles. This decreases the sense of stability in the joint (Forkin 2000: 247; Rene et al 2002: 112-113).

The nervous system is related to musculoskeletal system as muscles include self-sensory receptors that contain muscular spindles. In addition, tendons contain Golgi apparatus. Furthermore, joints contain sensory receptors that work on detecting range of motion, tension on tendons and over pressure on joints. This sensation is encoded into sensory neural signal sent via the spinal cord to the brain through special paths till it reaches cerebellum and cortex. After decoding the signal, it is sent through motor

nerves to muscles perform the required movement along the required range of motion or lifting a weight if muscular power is sufficient for that. The function of the nervous system is to respond to signals of musculoskeletal system and to send orders to muscles to perform the required effort (Kerry et al 2002: 507; Vojko et al 2002: 228).

Improving self-sensory receptors is vital for avoiding ankle sprain injuries, especially in people with previous history of repeated injuries. Athletes with weak control of weak balance can keep balance only for short periods. Therefore, they are more vulnerable to repeated ankle ligament ruptures. When a ligament is injured, neural terminals transmitting self-signals to the brain become less effective and this leads to repeated injuries in the future. This makes the athlete less effective compared to pre-injury level (Andrina & Robyn 2004: 543).

Balance exercises and self-sensory receptors drills are vital for restoring spatial perception through retraining with exercises like standing and walking on various surfaces and one-leg balance. These receptors are vital for transmitting sensory signals to the central nervous system. This stimulates one of the receptors with spatial and positional stimuli (Brandt 2006: 216).

Ankle sprain is a major problem that faces athletes during sports activities. It may lead the athlete to stop playing for a while and this decreases physical and technical fitness. It also may represent a physical and psychological block with negative effects if the athlete tries to return to training before full recovery just to get rid of the negative mood. Of course, this

may lead the injury to be worse or even repeated during the season.

Positive effects of improving balance on stability of the injured ankle are clear. Measuring balance is a technique for evaluating the degree of post-traumatic sensory limitation as the human body contains proprioceptors that send messages about body position and movements to the brain. In case of disorders or injuries in the ankle, messages are sent to the brain to modify body position and decrease pain (Timothy et al 2006: 187; Velhagen 2004: 886).

When joint injuries occur due to sports activities or other causes like disease or aging, signals sent by motor receptors of tendons and muscles are distorted leading to lose of local sensation. Evaluation of body position and balance are techniques used to diagnose post-traumatic sensory defects. Body stability is an important test to measure the degree of swinging, control and leaning. Before return to sport, the athlete with previous injury should restore the ability to keep balance and maintain body posture against gravity. This makes balance evaluation crucial for identifying the patient's ability to maintain balance, as balance is a basic physical quality that athletes can never perform sports movements without (Carl Mattacola & Maureen 2002: 425; Hong & Chan 2004: 53; Tawfiq 2005: 146-147).

Aim:

This research aims to identify the effectiveness of balance exercises on restoring the stability and functional efficiency of ankle joint.

Hypothesis:

Balance exercises improve stability and functional efficiency of ankle joint.

2. Methods:

Approach:

The researcher used the experimental approach (two-group design) with pre- and post-measurements.

Participants:

Participants (n=10) were purposefully chosen from soccer players of Al-Qadesia Sports Club – Kuwait. They were divided into two equivalent groups. The experimental group (n=5) contained players with functional disorder and instability of ankle joint (right foot) because of repeated ankle sprain injury. The control group (n=5) included players who were free of any ankle injuries. Participants were recruited according to the following criteria:

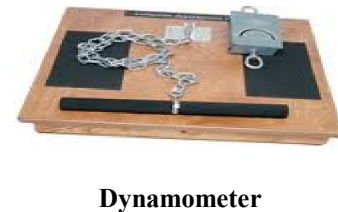
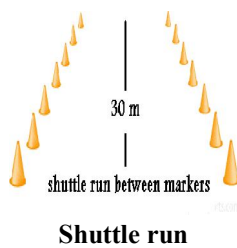
- They are all able to be punctual in attending all stages of application
- All members of the experimental group (n=5) suffer from functional disorder and instability of ankle joint (right foot)
- All members of control group (n=5) are free of any ankle injuries
- Diagnosis is done by a specialized physician

The researcher normalized basic data of participants (age – height – weight) as seen in table (1).

Table (1): mean, SD and skewness of age, height and weight for participants (n=10)

s	Variables Statistics	Measurement	Participants		
			Mean	SD	Squewness
1	Age	Year	23.32	0.30	-0.23
2	Height	Cm	179.58	2.84	0.21
3	Weight	Kg	73.33	0.93	0.41

Table (1) indicated that skewness values were between (±3). This indicates data normality.



Data collection instruments:

1. Data recording form
2. Medical balance for measuring weights (kg)
3. Trampoline
4. Plastic cones
5. Measuring tape

6. Stop watch
7. A dynamometer for measuring lower limb extension
8. Biodex Stability system for measuring right foot balance

Study variables:

1. Vertical jumping height with right foot (cm)
2. Lower limb extension with a dynamometer (kg)
3. Performance time with shuttle run (30 sec) (sec)
4. Right foot balance with Biodex Stability System (degree)

Balance exercises:

1. All exercises aim to increase stability of ankle joint through improving the functionality of proprioceptors
2. All exercises are used as tests to identify improvements in stability and balance of the injured ankle and improvements of proprioceptors functions
3. All exercises are applied for (6) weeks (3 days per week)
4. All exercises are applied individually
5. All exercises are applied according to range of pain

Procedures:

- The main study was applied from 15-6-2017 to 26-7-2017. All exercises were explained before performance. The researcher validated tools and instruments used in the research.
- Pre-measurements of all research variables were taken for all participants before main application

- Balance exercises were applied to the experimental (injured) group only while the control group followed normal training schedule

- Vertical jump for right foot was applied using single leg stance without further aids. Max height for each player was recorded. (Bosco et al 2000: 274)

- Lower limb extension for the right foot was performed using a dynamometer to measure joint endurance range (Heinonen et al 1999: 311).

- Shuttle run (30 sec) was measured before and after exercises (Baker et al 1999: 229)

- Right foot stability exercises were performed using Biodex Stability System and balance was measured before and after exercises (Smith & Arnold 2002: 95)

- All exercises are applied according to range of pain

- Exercises are terminated in cases of pain, shaking, joint instability or exhaustion

- Post-measurements were taken for all participants (both groups)

Statistical treatment:

The researcher used SPSS software to calculate the following: mean – SD – skewness – difference significance – (t) test – improvement percentage.

3. Results:

Table (2): Pre- and Post-measurements of the experimental group on all research variables (n=5)

S	Tests	Measurement	Pre-	Post-
1	Vertical jump	Cm	30.30	42.65
2	Lower limb extension strength	Kg	6.30	10.10
3	Shuttle run	Minute	11.00	8.12
4	Stability index	Degree	2.03	3.16

Table (2) showed means of pre- and post-measurements of the experimental group on all research variables.

Table (3): Pre- and Post-measurements of the control group on all research variables (n=5)

S	Tests	Measurement	Control	
			Pre-	Post-
1	Vertical jump	Cm	41.44	42.84
2	Lower limb extension strength	Kg	10.86	10.88
3	Shuttle run	Minute	7.58	7.88
4	Stability index	Degree	3.36	3.64

Table (3) showed means of pre- and post-measurements of the control group on all research variables.

Table (4): Difference significance between pre- and post-measurements of both groups

Tests	Measurement	Pre-		Post-		Sum of square deviation	Difference mean	(t)
		Mean	SD±	Mean	SD±			
Vertical jump	Cm	30.30	3.95	42.65	1.89	4.64	12.35	5.95
Lower limb extension strength	Kg	6.30	0.54	10.10	0.26	0.38	3.80	22.03
Shuttle run	Minute	11.00	0.16	8.12	0.29	0.16	2.88	39.19
Stability index	Degree	2.03	0.25	3.16	0.25	0.25	1.13	10.45

(t) table value on $P \leq 0.05 = 2.78$

Table (4) indicated statistically significant differences between pre- and post-measurements on all tests as (t) calculated values were (59.59, 22.03,

39.19 and 10.45) respectively. These values are higher than (t) table value (2.78). this indicates statistically significant differences in favor of post-measurements.

Table (5): Improvement percentages between pre- and post-measurements of the experimental group on all research variables (n=5)

S	Tests	Measurement	Pre-	Post-	Improvement percentage (%)
1	Vertical jump	Cm	30.30	42.65	40.79%
2	Lower limb extension strength	Kg	6.30	10.10	60.32%
3	Shuttle run	Minute	11.00	8.12	26.19%
4	Stability index	Degree	2.03	3.16	55.66%

Table (5) indicated that improvement percentages ranged from 26.19% to 60.32%.

4. Discussion:

Results shown in tables (3, 4 and 5) indicated statistically significant differences between pre- and post-measurements of the experimental group in favor of post-measurements. Improvement percentages for vertical jump, lower limb extension strength, shuttle run, and stability index are 40.79%, 60.32%, 26.19% and 55.66% respectively.

These improvements are due to improvements of proprioceptors that affect stability and body position greatly. Decrease in proprioceptors' function is greater during old age and this increases body leaning in elderly population. Balance exercises stimulate proprioceptors to maintain balance in old age and athletic performance. These exercises aim to restore neuromuscular activity to normal and sustain transmission of information via surrounding proprioceptors. (Hong & Chan 2004: 50-54).

There are several input/output pathways of the nervous system that enable the body to maintain balance during sports and daily life activities (Timothy & James 2006: 19).

There are common systems that control muscle movement, stability and balance. These include kinesthetic terminals, proprioceptors and Golgi apparatus in ligaments and tendons. These systems contribute in maintaining balance while performing various activities (Guyton & Hall 2006: 575; Edward et al 2005: 201; Abd Al-Baseer 2007: 37).

Balance exercises don't depend only on strength, but also on other muscular processes activated by proprioceptors. The effects of these exercises on the nervous system are the prime movers for muscles as it leads to accuracy and coordination to activate all working muscles. Neuromuscular coordination leads to achieve max strength in the desired direction (Carroll et al 2001: 837; Sussan et al 2006: 482).

Lack of control over muscle contractions indicates deficiency in sending information through proprioceptors. This means that neural work shifts from controlling power to generating movement in the

right direction, angle and magnitude to maintain movement of body parts and to assure that neural signals are perceived. (Eills & Rosen 2001: 991-998).

Balance exercises also control joint position in individuals with functional disorder of ankle joint and improve general balance. In addition, these exercises train proprioceptors of lower limb as it contributes in ending muscular imbalance in muscles surrounding the injured joint through increasing the functional efficiency of proprioceptors. This is reflected on the neural function and improves joint balance (Jeffrey 2004: 67; Mabec 2002: 151).

Some studies indicated the importance of central and peripheral stimulation of these joints to improve the function of proprioceptors and joint condition in addition to improving the performance level of motor skills (Palma 2005: 257)

Ankle joint injuries lead to direct weakness of autonomic signals transmitted through proprioceptors as these injuries lead to ruptures and damage of neural fibers. This leads proprioceptors to lose its role. One-leg jump, leg push, kneeling, stairs climbing and stability exercises help regaining and improving the function of proprioceptors (Paynek & Lalian 2006: 221-225).

The researcher thinks that these improvements are due to balance exercises that linked performance to pain degree and its effects on improving stability of the ankle joint and function of proprioceptors.

Balance, flexibility and strength exercises in addition to movements exceeding normal range are very important in overlap training to induce adaptations in proprioceptors. These exercises decrease the sense of instability of ankle joint after sprain injuries. Balance exercises programs lead to improvements in total balance of the injured joint in addition to decreasing the probability of injury return (Benjamin 2000: 569; Bruhn 2004: 58).

Balance exercises have positive effects on stimulating neural stimulus and activating neuro-motor

system, leading to improvements in body position and balance (Gruber & Gollhofer 2004: 103).

Balance exercises maintain balance and prevent falls in elderly population. Balance and strength exercises represent two clear indications of functional performance stability (Timothy & James 2006: 2015).

Ankle injuries decrease the ability of joint proprioceptors due to damage of micro-proprioceptors in ligaments, skin and muscles. It leads to a sense of joint instability. Balance exercises improve the function of proprioceptors (James et al 2003: 131).

Six weeks of muscular strength and balance exercises induce restoration of range of motion, strength and function of proprioceptors in addition to motor control and decreased injury risks (Polona 2004: 321).

Pain accompanying ankle joint injuries after some time of treatment is due to weakness of muscles and ligaments, in addition to lack of control over joint movement. The optimum time for strength exercises is immediately after balance exercises as these exercises increase responsiveness to neural signals and improve proprioceptors function (Fatih et al 2001: 197-198; Heinonen et al 1999: 311).

Strength is a crucial factor in most sports and it can be improved through short-term special training programs. There are several explanations for the relationship between neuro-muscular activity and strength. Increased rate of strength development depends on neuro-muscular coordination in producing power. This requires adaptation and quick response in addition to synchronization among motor units and quick contractions of working muscles (Travis et al 2001: 285-290).

Dynamic balance is a major component of physical fitness, not only for preventing falls in elderly population, but also for improving sports performance of athletes. There are several tests for dynamic balance, including circular movements (Mita et al 2008: 316).

Shuttle run is important for evaluating dynamic balance and quickness. It depends on coordinating several factors like strength, flexibility, balance and speed. Stability of prime movers and joints lead to improving shuttle run (Baker 1999: 231).

Results shown in table (2 and 3) indicated significant improvements of all research variables that are very close to normal for stability of injured joint in favor of the experimental group. Means of the experimental and control groups are (42.65 cm – 42.84 cm) for vertical jump, (10.10 kg – 10.88 kg) for lower limb extension, (8.12 sec – 7.88 sec) for shuttle run and (3.16 degrees – 3.64 degrees) for balance. This is consistent with Al-Husainy (2006), Carrie et al (2005), Amy & Christina (2005) and Hassan (2002) who indicated the importance of using balance exercises in

rehabilitation programs for improving stability of the injured joint and proprioceptors function.

5. Conclusions:

According to this research aim, methods and results, the researcher concluded the following:

1. The recommended balance exercises improved stability of the injured ankle joint.
2. The recommended balance exercises improved function of the injured ankle joint.
3. The recommended balance exercises fully rehabilitated the injured ankle joint.
4. The recommended balance exercises improved confidence and decreased fears of lack of stability among injured athletes.
5. The recommended balance exercises improved proprioceptors function of the injured ankle joint.

6. Recommendations:

According to these conclusions, the researcher recommended the following:

1. It is important to use balance exercises during rehabilitation.
2. It is important to use balance exercises in rehabilitative programs, especially at the final stage before return to sport.
3. More studies are needed to explain the relationship between ankle joint function and proprioceptors function in joint and muscles.
4. Physiological variables and neural capacity efficiency are vital indicators for treatment and recovery.

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