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Effectiveness of deep water running and muscular endurance training on running in athlete with post posterior tibial stress fracture

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Abstract
Background of the study: Stress fractures refer to fractures occurring in the bone due to a mismatch of bone strength and chronic mechanical stress placed upon the bone. Stress fractures represent a spectrum of injuries ranging from periostitis, caused by inflammation of periosteum, to a complete stress fracture that includes a full cortical break. Prevalence of tibial stress fracture is greater in high impact activities like running sports. Some reports indicate that up to 20% of elite runners may suffer from some sort of stress fracture. Incidence in National Collegiate Athletic Association (NCCA) athletic populations is reported at around 5.7 stress fracture per 1,00,000 athletic encounters, although this rate is significantly higher in (>20/1,00,000). The tibia is implicated in between 20% and 60% of stress injuries, depending of the sport and level of play. Age- Tibial stress fracture often presents in young adults, active patients but may occur in patients of all age. Sex-evidence suggests that stress fracture common in females than males. Stress fracture is the most common injury occurs in athletes that leads to severe pain, swelling, limited mobility and reduced performance. The purpose of the study was Deep water running training and muscular endurance training showed improve running in post posterior tibial stress fracture in athlete.
Objectives: The study's primary objective was to find out the effectiveness of deep water running and muscular endurance training on running in athlete with post posterior tibial stress fracture.
Subjects and Methods: This is a single case study, in which a 17 year old male involved in high school athletics middle distance running had a history of pain for 3 weeks along with training. He was diagnosed with posterior tibial stress fracture. He had given the deep water running training and muscular endurance training. The pre and post- test values are taken using cooper's test and University of Wisconsin Running Injury and Recovery Index (UWRI). The treatment duration was 8weeks.
Result: The pre and post-test values was taken using University of Wisconsin Running and Recovery Index (UWRI) was 4 and 36.
The 2nd week and post-test values of coopers test were 800 m and 3000 m. Hence, the statistical report states that there were significant increases of running capacity in an athlete with post posterior tibial stress fracture.
Conclusion: Hence, it concluded that after 8 weeks of treatment there was statistically significant in the application of deep water running training and muscular endurance training in improving the running capacity in athlete with post posterior tibial stress fracture.
Clinical implication: Deep water running training and muscular endurance training are found to produce significant effect to manage running in athlete with post posterior tibial stress.

Keywords: Post posterior tibial stress fracture, muscular endurance training, deep water running training, coopers test, university of Wisconsin running and recovery index

Introduction
A Fracture is a discontinuity in a bone (or cartilage) resulting from mechanical forces that exceed the bone's ability to withstand them [1]. Fractures can occur in variety of methods.

- A normal bone subjected to acute overwhelming force, usually in the setting of trauma.
- Weakened bone from a focal lesion (e.g. Metastasis, or bone cyst) known as pathological fractures.
- Weakened bone due to metabolic abnormalities (e.g. Osteoporosis) or less frequently, genetic abnormalities (e.g. Osteogenesis imperfecta). Resulting in insufficiency fractures.

Stress fractures referred to fractures occurring in the bone due to a mismatch of bone

strength and chronic mechanical stress placed upon the bone [3]. Stress fracture represents a spectrum of injuries ranging from periostitis, caused by inflammation of periosteum, to a complete stress fracture that includes a full cortical break.

They are relatively common overuse injuries in athletes' caused by repetitive sub maximal loading on a bone over a time. Often seen in running and jumping athletes and are associated with increased volume or intensity of training work load. Most common in the lower extremities are specific to the sport. Upper extremity stress injuries (Usually of ulna) are much less common and are also the result of overuse and effective [4]. Stress fractures frequently occur in tibia, the larger of the two bones that make shin. Tibial stress fracture is common among athletes which is usually caused by overuse and can significantly interfere with exercises and sports activity [5].

Prevalence of tibial stress fracture is greater in high impact activities like running sports. Some reports indicate that up to 20% of elite runners may suffer from some sort of stress fracture. Incidence in National Collegiate Athletic Association (NCCA) athletic populations is reported at around 5.7 stress fracture per 1,00,000 athletic encounters, although this rate is significantly higher in (>20/1,00,000). The tibia is implicated in between 20% and 60% of stress injuries, depending of the sport and level of play. Age-Tibial stress fracture often presents in young adults, active patients but may occur in patients of all age. Sex-evidence suggests that stress fracture common in females than males [6].

Stress fractures of the tibia are typically caused by too much stress placed on the tibia and surrounding muscles. This injury usually happens due to repetitive, high-impact exercise over a long period of time. Athletes may be at greater risk when they initiate a new training program or increase the volume or intensity of their normal running or exercise regimen. Stress fractures.

of the tibia are most common in these sports: Short distance running/ sprinting, cross country running, basketball, soccer. Pain is the most common symptom of a stress fracture of the tibia. Pain usually starts gradually, and becomes localized on a small area of the shin. Typically, pain is first noticed toward the end of intense exercise, but gradually begins to occur earlier on. Common symptoms also includes, pain that gets worse with activity, as the condition progresses, pain whose intensity and duration gradually increase, localized swelling [5] The investigation procedure includes, bone scans for many years been regarded as the gold standard for evaluating stress-induced injuries. Radiography, Two thirds of initial radiographs are normal early in the course of a stress fracture half ultimately prove positive once healing begins to occur (Specific but not sensitive) [8]. MRI is an effective diagnostic technique in patients who show strong clinical manifestations of a stress fracture but have normal initial radiographs. Most tibial shaft stress injuries can be managed conservatively; this includes activity restriction and protected weight-bearing. If the "dreaded black line" is present and violates the anterior cortex, then ORIF with intra medullary tibial nailing or plating may be indicated. This depends on the duration of conservative treatment and the patient's occupation and the sport in which the patient participates.

On exploration of the literature several treatment options have been described to improve running in stress fracture physiotherapy treatment such as gait retraining, resistance training, shallow water running, body weighted treadmill training are given to patient with stress fracture. Besides the technique showed above the deep water running training and muscular endurance training showed better results.

Muscle endurance is the ability of a muscle to contract repeatedly against a load (resistance), generate and sustain tension, and resist fatigue over extended period of time. The term aerobic power sometimes used interchange with muscle endurance. Maintenance of balance and proper alignment of the body segments requires sustained control (endurance) by the postural muscles. In fact, almost all daily living tasks require some degree of muscle and cardio pulmonary endurance. Muscle endurance training (endurance exercise) is characterized by having a muscle contract and lift or lower a light load for many repetitions or sustain a muscle contraction for an extended period of time. The key parameters of muscle endurance training are low intensity muscle contractions, a large number of repetitions and a prolonged time period. Unlike strength training, muscles adapt to endurance training by increases in their oxidative and metabolic capacities, which allows better delivery and use of oxygen [14].

Deep water running training (DWR) is a form of cross-training that addresses runner sport specificity and became an effective form of training for runner's lower limb stress fractures. DWR allows the runner to stimulate the mechanics of running, achieves similar metabolic response to on-land running, and has been shown to maintain on-land performance. Several properties of water allow it to be an ideal training setting for injured runner. Buoyancy decreases the weight of the submerged body placing less pressure on bones and soft tissue structures. Hydrostatic pressure has been postulated to aid in cardio vascular function by promoting venous return [15].

Methodology

Study design

The study was a single case study.

Case history

A 17-year-old male involved in high school athletics middle distance running had a history of pain for 3 weeks along with training. He was running up to300 km per week on streets and cross country. He was diagnosed with posterior tibial stress fracture, but despite the lower leg pain he continued running. He had a bilateral posterior tibial stress fracture. One year later he was brought to the emergency department after having sustained injury to the right lower leg while running in a middle-distance race bilateral tibial stress which one side complete and the opposite side had developed simultaneously, that was treated surgically via exchange inter medullary nailing is reported. After one month has started deep water running training and muscular endurance training.

Methods

The need and objective of the study was clearly explained to the ethical committee of PPG college of physiotherapy and permission was obtained. The subject selected for the study from the OUT-patient department in the ppg college of physiotherapy was informed about the procedures and the risk factors involved in the study and after that informed consent form was received from the patient for the study.

The patient received Deep water running training and

muscular endurance training for 8 weeks (i.e. 3 alternate days for each technique for 6 days a week). The pre-test and post-test value was measured using Cooper's test and UWRI Questionnaire. The data were collected and documented before and after the first and last week of the study.

Description of technical intervention

Deep water running training

The Deep water running training (DWR) is a form of cross-training that addresses runner sport specificity and became an effective form of training for runners lower limb stress fractures. DWR allows the runner to stimulate the mechanics of running, achieves similar metabolic response to on-land running, and has been shown to maintain on-land performance. Several properties of water allow it to be an ideal training setting for injured runner. Buoyancy decreases the weight of the submerged body placing less pressure on bones and soft tissue structures. Hydrostatic pressure has been postulated to aid in cardio vascular function by promoting venous return [15].

Muscular endurance training

Muscle endurance is the ability of a muscle to contract repeatedly against a load (resistance), generate and sustain tension, and resist fatigue over extended period of time. The term aerobic power sometimes used interchange with muscle endurance. Maintenance of balance and proper alignment of the body segments requires sustained control (endurance) by the postural muscles. In fact, almost all daily living tasks require some degree of muscle and cardio pulmonary endurance. Muscle endurance training (endurance exercise) is characterized by having a muscle contract and lift or lower a light load for many repetitions or sustain a muscle contraction for an extended period of time. The key parameters of muscle endurance training are low intensity muscle contractions, a large number of repetitions and a prolonged time period. Unlike strength training, muscles adapt to endurance training by increases in their oxidative and metabolic capacities, which allows better delivery and use of oxygen [14].

Data analysis

The demographic presentation of the subject is shown in table.1

Table 1: Patient description

S. No	Patient description	Measures
1	Age	17 YRS
2	Gender	MALE
3	Height	164 CM
4	Weight	48 KG

Table 2; Data analysis of analysis of university of Wisconsin running injury and recovery index

Outcome Measure	Day 1	2nd Week	4th Week	6th Week	8th Week
Uwri	4	9	16	27	36

Table 3: Data analysis of Coopers test

Outcome measure	2nd week	4th week	6th week	8th week
Coopers test	800 m	1700 m	2300 m	3000 m

Result

The Pre- test value of UWRI SCALE was 4 and 2nd week value of COOPER'S TEST was 800 m and the Post- test value of UWRI SCALE & COOPER'S TEST was 36 and 3000 m.

Discussion

This study is to find the effectiveness of Deep water running and Muscular endurance training on running in posterior tibial stress fracture in athlete.

The studies have shown that the two sport-specific cross-training methods for injured runners include deep water run training and Muscular endurance training. They are useful tools for any clinician who treats runners. In addition to the greater specificity of exercise, they allow for reduced stress on injured tissue and joints, allow maintenance of cardio respiratory fitness, have a training effect and potentially can decrease injury risk from over training. Both DWR and Muscular endurance training, thus can be helpful for the rehabilitating injured runner who needs rest from land-based running to heal, as well as the high-mileage runner who is looking for a supplemental training modality with less risk of overuse injury.

Brian C Liem, *et al*., They conducted a study on the DWR with the several studies, Town and Bradley found that DWR-trained varsity cross-country runners reached V˙O2max and maximum heart rate values 73% and 86% of TMR, respectively, when asked to perform exercise to volitional exhaustion. The reduction in these cardio respiratory physiologic parameters found in DWR compared to TMR is not as pronounced in those with previous running experience (and possibly better mechanics) and is still adequate for training and cardio respiratory fitness. In cooler water, HR is as much as 15% less than land-based running at the same intensity; however, in warmer water, HR is almost equivalent. However even with a reduced training HR, the aerobic benefit still. Comparing the kinematics of DWR with land running demonstrates a significantly greater amount (50% to 87%) of hip flexion achieved in DWR. In addition, DWR can be used for training the uninjured high-mileage runner who wishes to maintain higher weekly mileage by using DWR on recovery days as a supplemental training tool. Thus the study concluded that DWR is a useful tool for any clinician who treats runners. In addition to the greater specificity of exercise, they allow for reduced stress on injured tissue and joints, allow maintenance of cardio respiratory fitness, and have a training effect and potentially can decrease injury risk from overtraining. DWR thus can be helpful for the rehabilitating injured runner who needs rest from land-based running to heal, as well as the high-mileage runner who is looking for a supplemental training modality with less risk of overuse injury.

Liem, BrianC.MD,*et al*., They conducted a study on rehabilitation and return to running in stress fracture athletes on muscular endurance training, One of the major functions of muscle is to absorb impact forces during running. Fatigued muscles are thought to be less able to absorb force and thus, they transmit higher forces to adjacent bone. Local muscle fatigue has been associated with higher vertical ground reaction forces during the stance phase of running. In a study by Christina, 11 female runners under went fatiguing exercises of the ankle dorsiflexors and inverters prior to treadmill running (TMR). They found that the loading rate of impact peak force was higher in post fatigue

runs compared to pre fatigue runs. As such building muscle endurance is an essential component of rehabilitation after lower leg stress injury. In general, high-repetition, low-resistance exercises build endurance. For muscular endurance training, the American College of Sports Medicine recommends whole body training two to three times per week. Loading intensity varies depending on the skill level of the athletes, with novice athletes performing light loads for 10 to 15 repetitions, while advanced athletes train with various loads for 10 to 25 repetitions. Thus, the study concludes that the muscular endurance training is an effective rehabilitation exercise in athletes with stress fracture. Previous studies concluded that, deep water running and muscular endurance training have positive effects on running performance in athletes' with Tibial stress fracture. Deep water running (DWR) is a form of cross-training that addresses runner sport specificity and cam be an effective form of training for runners lower limb stress fractures. DWR allows the runner to stimulate the mechanics of running, achieves similar metabolic response to on-land running, and has been shown to maintain on-land performance. Several properties of water allow it to be an ideal training setting for injured runner. Buoyancy decreases the weight of the submerged body placing less pressure on bones and soft tissue structures. Hydrostatic pressure has been postulated to aid in cardio vascular function by promoting venous return. Muscle endurance is the ability of a muscle to contract repeatedly against a load generates and sustain tension, and resist fatigue over extended period of time. The term aerobic power sometimes used inter changeably with muscle endurance. Maintenance of balance and proper alignment of the body segments requires sustained control (endurance) by the postural muscles.

In fact, almost all daily living tasks require some degree of muscle and cardio pulmonary endurance. Muscle endurance training (endurance exercise) is characterized by having a muscle contract and lifts or lowers a light load for many repetitions or sustains a muscle contraction for an extended period of time. The key parameters of muscle endurance training are low intensity muscle contractions, a large number of repetitions and a prolonged time period. Unlike strength training, muscles adapt to endurance training by increases in their oxidative and metabolic capacities, which allows better delivery and use of oxygen.

A subject was selected from Ashwin Multi- Specialty Hospital, Coimbatore. The objectives and need of the study were clearly explained to the ethical committee of PPG College of Physiotherapy and the permission was obtained. After that the patient received clear explanation in detail about the aim and intervention of the study. Inform consent form was received from the patient prior to the study. The pre score is taken with Cooper's test and UWRI scale. The patient received deep water running and muscular endurance training in alternate days for three sessions per week. The post test scores were evaluated and recorded at the interval of every 2 weeks for 8 weeks. With reference to the statistical analysis and interpretation it's noticed that, in this study the Deep water running and Muscular endurance training were considered as effective form of training for runners with tibial stress fracture.

Limitations

1. This was a single case study.
2. The effectiveness of the treatment varies from person to person.
3. The study duration was short.
4. The study was practiced with only specific tasks.
5. The study does not produce enough demographic data on the effectiveness for wide range patients.

Suggestions

1. Further study can be conducted with Experimental study or Comparative study.
2. Further study can be done in different age groups.
3. The study can be done with other interventions.

Conclusion

Hence, it concluded that after 8 weeks of treatment there was statistically significant in the application of Deep water running training and Muscular endurance training in improving the running capacity in athlete with Posterior tibial stress fracture.

Conflicts of interest

No potential conflict of interest was reported by authors.

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Nothing to report.

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