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RESEARCH ARTICLE

EFFECT OF STRING VIBRATION DAMPER OF TENNIS RACKET ON MYOELECTRIC ACTIVITY OF WRIST EXTENSORS

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ABSTRACT

The purpose of this study was to investigate the effect of String Vibration Damper on the myoelectric activity of the wrist extensors during the impact phase of backhand stroke technique.15 elite and 15 novice tennis players with an age ranging from18-25 years volunteered to participate in this study. Only one racket was used and was impacted by a pressurized ball. That was subjected to a constant velocity. The ball impacts were directed the racket throat area with and without using the String Vibration Damper. The participants were not allowed to see the ball impacts, as stand was placed between the participant and the racket. The experiment was repeated three times at the same day with rest periods in-between. The wrist extensors EMG data were collected with and without using the String Vibration Damper. Results revealed that there was no significant effect of using String Vibration Damper on the mean values of maximum EMG activity of the examined muscles ($P>0.05$). But, the decrease in the myoelectric activity of tennis beginners is significant, indicated that it may be preferable to use the string vibration damper with tennis beginners to protect them against the occurrence of lateral elbow pain. In conclusion, the results of the study do not support the concept of using the String Vibration Damper to reduce the myoelectric activity of the wrist extensor during tennis playing.

INTRODUCTION

Tennis playing is a popular sport which is being practiced for more than 2000 years. It is a game in which a ball is batted back and forth with a racket. There are four basic tennis strokes; the forehand, two-handed backhand, one-handed backhand, and the serve (Shamus and Shamus, 2001). The one-handed backhand stroke constitutes four phases: preparation, acceleration, contact and follow-through (Groppel and Nirschl, 1986 and Wu *et al*., 2001). The preparation phase begins with the first motion of the racket-arm during the back swing and ends with the first forward motion of the racket. The acceleration phase begins with the forward movement of the racket-arm and ends with the ball contact phase. The follow-through phase begins with the ball contact and ends with the completion of the stroke (Morris *et al*., 1989). Tennis is a complex physical sport requiring hand-eye coordination and full body participation to run, position, swing and hit. Because of these demands, endurance, flexibility and muscle conditioning exercises are important to prevent injuries (Wu *et al*., 2001). Racket sports injuries are becoming a matter of increasing concern in the world of sports medicine. The number of participants is rising.

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However, the equipment and environmental factors are still not made for protecting these participants against the injury that may occur (Baxter-Jones *et al*., 1995). Epidemiological data have shown that tennis injuries are primarily caused by overuse (Pluim and Safran, 2004). Loading may be applied to the body externally (ground reaction force and vibration) or internally (muscle force and torque) (Elliott *et al*., 2003). In tennis playing, most of the reported information about tennis injuries has been devoted to "tennis elbow" (Chard and Hazleman, 1989). Tennis elbow (humeral epicondylitis) occurs with pain and tenderness at the lateral side of the players' elbow joint (Nirchl, 1974). Overexertion of the extensor carpi radialis brevis (ECRB) muscle may be one of the important etiological factors for tennis elbow (Murtagh *et al*., 1988). Persons performing repetitive wrist movements appear to be at high risk for injury (Williams *et al*., 1989). Novice players are more likely to use repetitive wrist motions to produce strokes (wristy impact), and hence require greater force from wrist extensors (Berhang *et al*., 2000). During all sport activities, our bodies are exposed to external applied forces. These forces induce vibrations and oscillations within the tissue of the body. The tissue vibrations can be induced from impact related events where either a part of the body or sporting equipment colloids with an object. Example of this is the impact shocks that are experienced through the contact phase of backhand groundstroke. The force produced from the initial ball contact causes vibration that travels to the strings, across the racket, to the player's arm. (Cardinal *et al*., 2003).

Vibration is a mechanical stimulus that is characterized by an oscillatory motion. The biomechanical variables that determine its intensity are the frequency (measured in Hz) and amplitude (peak to peak displacement, in mm). Vibration has been studied extensively for its dangerous effect on humans at specific amplitudes and frequencies (Cardinal and Wakeling, 2005).

Tennis racket vibration is a popular, frequently misunderstood topic among tennis players. When tennis ball impacts a racket, the frame and strings respond very differently; vibrate with different frequencies and amplitudes. Roeter *et al*. (1996) showed that the fundamental mode of racket frame vibration has greater amplitude than string vibration immediately after impact. The frame has typical fundamental frequencies between 100 to 200 Hz, while the strings vibration is higher "often audible" frequencies. These low vibration frequencies which are applied to the hand of the player during impact leads to hand-arm discomfort (Reynolds, 2002). The initial impact with the ball causes vibration within soft tissues, after which the tissues continue to oscillate in free vibration manner (vibrating at their natural frequency). When the natural frequency of vibration coincides with the frequency of another external excitation (from another impact shock), a phenomenon known as (resonance) will be produced. The resonance is a dangerously large oscillation which leads to excessive deflections and failure of structures (Thomson, 1980).

The vibration might be the trigger that elicits "pain response" from tennis elbow sufferers or it may be the cause of micro-trauma that tears the connective tissue which ultimately ends up with tennis elbow. It may be possible to eliminate the pain of tennis elbow by altering the magnitude of vibration transmitted to the injured areas (Bauer *et al*., 2001). The magnitude of these large amplitude vibrations (resonances) can be reduced by damping from soft tissues. The damping mechanism is present in all oscillatory systems. Its effect is to remove energy from the system and to dissipate it as heat or to radiate it away. This heat results from the internal molecular friction inside the system of the material itself (Cardinal and Wakeling, 2005). From the above findings, tennis elbow has received attention through biomechanical studies aimed to prevention (Hatze, 1992). With tennis elbow, the focus has been on the equipment and technique aspects of this sport. The use of grip bands and counterforce braces to reduce vibration has been considered. Using smaller grip forces and using rackets that minimize the impact shock have been recommended to reduce the risk of tennis elbow (Knudson, 1991).

Several manufacturers' market small elastomeric vibration dampers. These devices are installed in string mesh of the racket and they become popular among tennis players (Claire *et al*., 1999). Some damper manufacturers claim that their products reduce hand-arm vibration discomfort during racket use but there is no evidence to support their claims. The aim of this study to examine the mechanical effect of string vibration damper devices on the myoelectric activity of the wrist extensors during the impact phase of one-handed backhand strokes.

Subjects

Thirty tennis players volunteered to participate in the study. They formed two groups; elite and novice groups. The elite group consists of 15 elite right handed tennis players who played tennis for 5-7 years and novice group consists of 15 novice right handed tennis players who played tennis for 1-2 years only. there average age was 21 (±7) years. There average height 173cm. there average weight was 69Kg.

Instrumentation

Prince Extender RAD ^{TM12} racket

A "Prince Extender RAD ^{TM12} racket " was tested (Fig.1). It is consisted of three main areas: racket head area, racket throat area, and racket handle area. The strings of the racket were made of nylon monofilament under tension of 200- 270 N (20-27 kg). The patterns of strings were 16 mains and 21 crossers. The mass of the racket was 0.3Kg. The racket frame was made of a hollow aluminum frame which transmits large amount of frame vibration to the players' hands. The racket length was 60.9 cm as measured from the top of the racket head to the base of the handle. The head of the racket was 25.71 cm wide. The handle measured 14.28 cm long, 3.15 cm wide and 3 cm deep with a grip length of 10.5 cm.

The commercially available "Head" string vibration damper was used. The head vibration damper was simple to install and remove from the strings (Fig.2).

The tennis ball machine (projectile) consisted of a long table made of wood with a movable arm made of metal placed on the top. This movable arm was connected with a spring that had a constant tension. The constant tension of the spring tended to project the tennis ball at a constant velocity through a velocity vector with the racket strings. This velocity vector made an angle approximately 120^{o} with the racket strings.

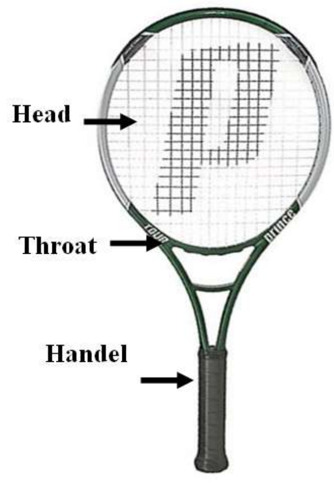

Fig. 1. Main three areas of Prince Extender RAD TM12 racket

The Pro's Pro pressurized standard tennis ball was used with a mass 0.057 Kg (2 ounces). A fixed bar (2 m long and 2.5 m high from the ground) was used to hang the racket. This bar placed the racket at a constant position in relation to the projectile. A stand was placed between the participant and the racket to prevent any testing effect on the participant A BIOPAC (MP100) EMG apparatus was used. This system consists of data acquisition unit with a common mode rejection ratio (CMRR) of 110 dB. The acquisition rate was set at 500 Hz. One channel was used to record changes in the pattern of EMG signals of the wrist extensors. These signals were passed through the pre-amplifier, analogue to digital converter and junction box. The main unit transfers the recorded signals to a computer with installed software to display, record and analyze the data. Acknowledge 3.7 software was used for analysis of the raw EMG signals.

Fig. 2. Head string vibration damper

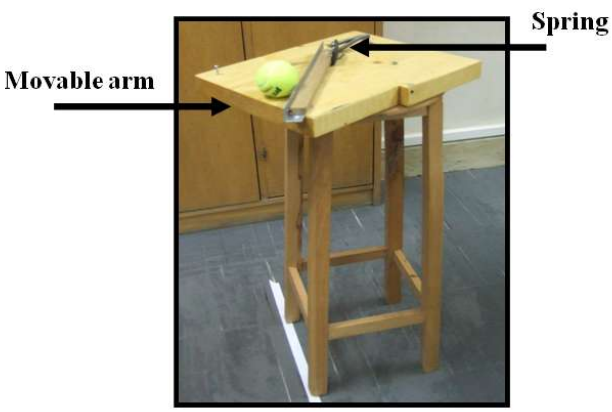

Fig. 3. The projectile of the ball with aconsistent spring tension

The myoelectric activity of the right wrist extensors was recorded using disposable Silver-Silver Chloride (Ag-AgCl) electrodes with an active surface area of 1cm^2 . The electrode consisted of a plastic foam material with a silver plate disc placed on one side and silver plate snap placed on the other side. Easily released protective papers were placed over the electrode adhesive surface. The electrodes were used to pick up the EMG signal from the skeletal muscles. They were secured in place with self-adhesive tape. A shock sensor, a piezoelectric impact detector, was used to detect any physical or mechanical stimulation. It was stacked to the center of the racket strings. It was connected to the EMG device by a cable of about 2 cm length. It detected the EMG activity of the wrist extensors at time of ball impact with racket strings.

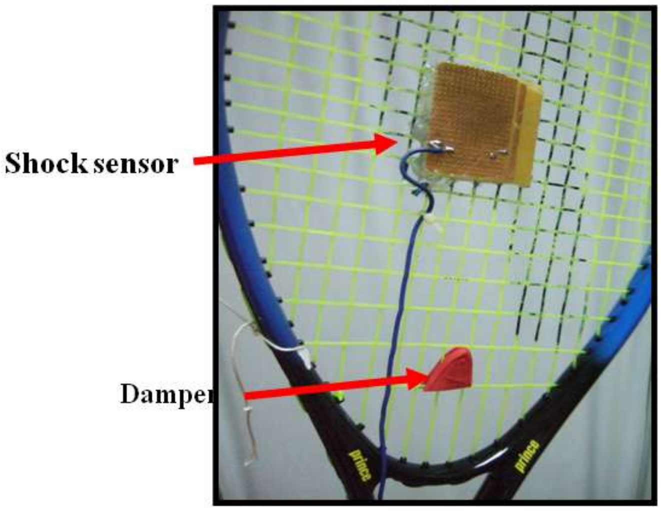

Fig. 4. Shock sensor at the center of the racket to detect the time of ball impact

Procedure

The following preparations were executed before the condition of each trial: Each participant was informed about the experimental process and the significance of the study. All participants signed consents. The projectile was put at a constant distance about 120 cm from the racket. The racket was hanged at a constant height about 92 cm from the fixed bar. The stand was placed between the racket and the participant .The ball was placed in front of the metallic arm of the projectile as a preparation to project it against the racket head. The EMG apparatus was set at a gain of 10,000 with a sampling frequency of 500 Hz. The participant's skin was shaved and cleaned thoroughly with alcohol to remove skin debris and to reduce the skin's resistance.

Surface disposable Ag/AgCl EMG electrodes were placed midway between the motor point and tendentious origin of the wrist extensors. The motor point of the wrist extensors was 3 cm distal to the lateral epicondylitis. The sites of motor point of wrist extensors were proposed by Delagi and Perotto (1980). The participants were begun to stand behind the stand. They were instructed to hold the racket firmly but not forcefully and to maintain the wrist in neutral position. An effort was made to ensure that the participants were in a typical stroking stance while holding the racket by the right hand in front of the projectile. The racket was impacted by the ball and allowed to back.

The EMG signals were concomitantly recorded and monitored on the screen. The time of ball impact was detected by the shock sensor .Each participant underwent three trials with the string vibration damper being installed on the racket strings. Three additional trials were carried out with the string vibration damper being removed from the strings.

RESULTS

The recorded EMG data from the right wrist extensors were collected and analyzed using STATGRAPHICS PLUS 3.0 program. The statistical significant difference between the two testing condition (with and without the use of String Vibration Damper) was studied using paired t-test. Statistical significance was set at P< 0.05. The finding showed that there was no significant difference in the EMG activity of the right wrist extensor in the elite tennis players with vs. without use of the String Vibration Damper conditions (6.76 ±1.7 6 vs 6.26 ±1.59, P=0.47).

game. Even though, the SVD did not reduce the hand-arm vibration that affects the myoelectric activity of the wrist extensors. It is expected that most of players use the SVD to eliminate the sound component of the string vibration.

This tiny piece of rubber tends to mute the strings similar to a guitar player muting strings during a song. The strings are still being hit, the shock is still being made, but the strings do not move in a way to create the normal sound that the players hear. The sound wave, like any wave, is a phenomenon which transports energy from one location to another.

Table 1. Descriptive statistics and paired t-test of the right wrist extensors at the impact phase in elite and novice tennis players

Group	Condition1 (with damper)	Condition2 (without damper)	Paired t-test		Group	Condition1 (with damper)	Condition2 (without damper	Paired t-test	
	Mean ± SD	Mean ± SD	T	P		Mean ± SD	Mean ± SD	T	P
Elite tennis player	6.76 ± 1.76	6.26 ± 1.59	0.73	0.47	Novice tennis players	5.4 ± 1.88	5.8 ± 1.89	–0.53	0.59

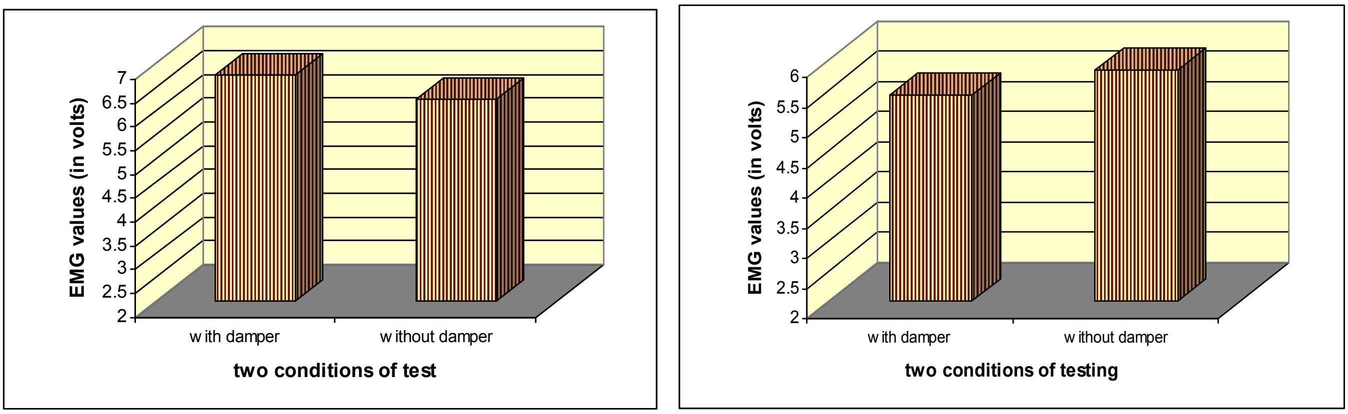

Fig. 5. The mean values of the EMG activity of the right wrist extensors in the impact phase of tennis with and without using the SVD in elite and novice tennis players

DISCUSSION

With the increased incidence of lateral epicondylitis development among the tennis players owing to increase vibration resulting from impact forces, certain devices referred to as String Vibration Damper began to appear. These devices claimed to decrease the amount of vibration and the incidence of lateral elbow pain. However, recently researches examined the effect of string vibration damper on reducing the vibration frequency; but they could not support these supposed (Norris, 1993). The current study was carried out to explore the effect of string vibration damper during ball impacts on the myoelectric activity of the wrist extensors. According to the obtained results of this study, there was no significant difference in the myoelectric activity of the wrist extensors with and without the use of SVD. The findings did not support the claim that the SVD reduces the impact myoelectric activity of the wrist extensors. Also, it may not support the claim that SVD makes elbow hurt less by reducing the muscle strain that is caused by vibration.

The participants in this study reported that they use SVD aiming to feel with less vibration and more comfort during the

As sound waves move through a medium, each particle of the medium vibrates at the same frequency. The muted sound is because the strings are not vibrating in a normal way. This is because the player's hand comes in contact with the strings and tends to reduce the energy by eliminating some of the sound waves. So, the player's hand acts as damper for the strings sound (Rassmussen, 2001). Regarding tennis playing, the difference felt is very little between using a vibration damper and not using it. The biggest noticeable difference is in the sound muting.

The insignificant difference in the myoelectric activity of the wrist extensors with using SVD is consistant with the findings of Claire *et al.* (1999). They found that the vibration traces recording by accelerometer that was mounted on the racket handle revealed that the SVD quickly absorbed high-frequency string vibration and slightly attenuated the low-frequency frame vibration. The low-frequency frame vibration was transmitted to the player's arm from the racket handle but had a little effect on the myoelectric activity of the wrist extensors. These were detected by the accelerometer and myoelectric analysis. According to Reynolds *et al.* (1977), it is expected that the participants would be more sensitive to the low-frequency (<180 Hz) fundamental frame vibration than the high-frequency (>180 Hz) string vibration. Reynolds and Keith (1977) observed that most of the vibration energy recorded at frequency range 100 to 200 Hz was directed towards the hand. It was localized and dissipated in the region of the hand and fingers that are in direct contact with the vibration handles. Also, Fritz (1991) indicated that at frequency above 100 Hz, the energy dissipated mainly by the dampers which were put near the exciter (ball impact). Without using the damper, this frequency was transmitted to the hand arm system; This might be the cause for the incidence of vibration induced white finger disease. So, this indicated that the high-frequency vibration has a short life in its traveling through the hand arm system and had no effect on the incidence of tennis elbow or the discomfort during the play. In this study, the amount of low-frequency frame vibration that was transmitted to the player's arm from the racket handle may be increased without using the SVD. It was responsible for the slight increase in the myoelectric activity of the novice tennis players. While, the in significant difference in the myoelectric activity of the elite tennis participants may be attributed to the increase in the muscle power. This is ensured by Cardinal and Wakeling (2005) who reported that the natural frequency of vibration system depends on its stiffness and mass. Within the skeletal muscles, each cross-bridge between the actin and myosin myofilaments generates some stiffness and so the soft tissue stiffness increases with the increasing in the muscle activity. In addition, Wakeling and Nigg (2001) showed that muscles can damp externally applied vibration and indeed more vibration energy is absorbed by activated muscles suggesting that the active cross-bridge cycling is an important part of the damping process.

From the previous findings, the slight decrease in the myoelectric activity of the wrist extensors of the elite tennis participants without the use of the SVD indicated that part of the myoelectric activity might be used to damp part of the vibration that reached the player's arm. In general, it is suggested that SVD remain a popular accessory among tennis players because of its acoustic reduction effects and psychological support rather than its mechanical advantage.

Conclusion

The string vibration damper has no mechanical effect on the tennis players. The slight decrease in the myoelectric activity of the right wrist extensors in the novice tennis players with using the String Vibration Damper may be beneficent in decreasing the load on the wrist extensors and reducing the incidence of lateral elbow pain.

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REFERENCES

Bauer JA, Lamb ML, Murray R and Chiumento A: The Effect of Tennis Elbow Braces on Vibration Transmitted through the Forearm; 1st "ed". United States, University of Florida, Tennis Association. 2001, Pp.600-610.

Baxter-Jones AD, Maffulli N and Helms P: Low injury rates in elite athletes. *International Journal of Sports Medicine*, 68 (3): 130-132, 1995.

Berhang MR, Cohen MS and Roderick J: The collateral ligaments of the elbow. *Journal of Biomechanics* 22 (2): 415-425, 2000. *Journal of Clinical Biomechanics* 16 (4): 25-30, 2001.

Cardinal M and Wakeling J: Whole body vibration exercise: are vibrations good for you? *British Journal of sports Medicine*, 39 (3): 585-589, 2005.

Cardinal M, Pope MH and Jone RL: The effect of whole body vibration on humans: dangerous or advantageous? *Acta Physiol. Hung.* 90: 195-206, 2003.

Chard MD and Hazleman BL: Tennis elbow- A reappraisal. *British Journal of Rheumatoid*, 38 (3): 186-190, 1989.

Claire L, Stroede R, Nobel L and walker HS: The effects of tennis racket vibration damper on the racket handle vibrations and discomfort following impact. *Journal of sports Science,* 17: 379-385, 1999.

Elliott B, Flesing G and Nicholls R: Technique effects on upper limb loading in tennis. *Journal Science of Medical Sports,* 35 (6): 76-87, 2003.

Fritz M: An improved biomechanical model for stimulating the strain on the hand-arm system under vibration stress. *Journal of Biomechanics,* 24 (12): 1165-1171, 1991.

Groppel M and Nirschl MD: Mechanical and electromyographyical analysis of the effect of various joint counterforce braces on the tennis player. *American Journal of Sports Medicine*, 14 (3): 195-199, 1986.

Hatze H: The effectiveness of grip bands in reducing racquet vibration transfer and slipping. *Medical Science of sports Exercise,* 24 (2): 226-230, 1992.

Knudson DV: factors affecting force loading on the hand in the tennis forehand. *Journal of Sports Medicine*, 31 (4): 527-531, 1991.

Morris M, Jobe F and Perry J: Electromyographic analysis of elbow function in tennis players. *American Journal of sports Medicine*, 17 (2): 241-247, 1989.

Murtagh M, Patricia RS and Jean-Pierre V: Effect of tonic vibration reflex on motor unit recruitment in human wrist extensor muscles. *Journal of Applied Physiology and Occupational Physiology,* 13 (1): 32-40, 1988.

Nirschl RP: The etiology and treatment of tennis elbow. American Journal of Sports Medicine 2 (3): 308-315, 1974.

Norris CM: Sports Injuries: Diagnosis and Management for Physiotherapist; 1st "ed". Oxford, Butterworth-Heinemann Ltd, 2002, Pp 295-297.

Pluim BM and Safran M: From Breakpoint to Advantage includes Description, Treatment and Prevention of All Tennis Injuries; Vista, USRSA, 2004, Pp.22-25.

Rassmussen G: Human Body Vibration Exposure and Its Measurement; 4th "ed". USA, Williams and Wilkins Company, 2001, Pp.22-35.

Reynolds DD and Keith RH: Hand-arm vibration: Part I: analytical model of the vibration response characteristics of the hand. *Journal of sound and vibration*, 51 (4): 237-253, 1977.

Reynolds DD, Standlee KG and Angevine EN: hand-arm vibration: Part III. Subjective response characteristics of individuals to hand-induced vibration. *Journal of sound and vibration,* 51 (2): 267-282, 1977.

Reynolds M: the one handed and two handed backhands in tennis. *Journal Sports Medicine,* 1: 47-68, 2002.

Roetert EP, Broady H, and Dillman CJ: the biomechanics of tennis elbow. An integrated approach. *Journal of Biomechanics*, 29 (4): 1531-1537, 1996.

Shamus E and Shamus J: Sports Injury Prevention and Rehabilitation; 1st "ed". New York, McGraw-Hill, 2001, Pp. 45-65.

Thomson T: Theory of Vibration with Application; 4th "ed". London, Champan and Hall, 1980, Pp.5-15.

Walkeling JM and Nigg BM: modification of soft tissue vibrations in the leg by muscular activity. *Journal of Applied Physiology,* 90 (4): 412-420, 2001.

Williams W, Van MW and Hlobil H: Incidence, severity, etiology and prevention of sports injuries. *American Journal of sports Medicine,* 3 (5): 205-212, 1989.

Wu S, Cross MT and Prentice WE: Comparison of ball and racquet impact force between two tennis backhand stroke techniques. *Journal of Orthopedic and Sports Physical Therapy,* 31 (5): 247-254, 2001.

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