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The Effect of Auditory and Vibration Stimulation on Proprioception of the Lower Extremity

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Abstract

Objectives: The purpose of this study was to vibration and auditory stimuli affected the sense of ankle, knee, and hip joint position. **Methods/Statistical Analysis:** 40 healthy male and female adults who did not undergo an operation for diseases relevant to ankle, knee and hip joints were recruited for this test. By dividing experiment group into auditory stimulus group, vibration stimulus group, auditory, vibration stimulus group, sense of position for ankle, knee and hip joints was measured and for control group, sense of position for ankle, knee and hip joints was measured without any intervention. In order to give excitation arousal to auditory stimulus group and vibration stimulus group, cheerful music was played to them and to give vibration stimulus to vibration stimulus group and auditory, vibration stimulus group, vibration stimulus was given to them. Test subjects were directed to remember target angle through exercise of 5 times including ankle joint 20o, knee joint 30o and hip joint 95o and then stop exercise when they thought to arrive at the first remembered angle after taking a rest. As measurement tool, isokinetic muscular strength test equipment was used. **Findings:** In auditory stimulus group, significant difference was represented in ankle joint and in vibration stimulus group (p<.05), such difference was represented in ankle, knee and hip joints (p<.05). However, its mean value did not show any significant difference (p>.05). **Improvements/Applications:** As a result, this research has proved that vibration stimulates the ankle, knee, hip joint position sense and auditory stimulation of the senses is the effect on the position of the ankle stimulation.

Keywords: Ankle Position Sense, Auditory Stimulation, Hip Position Sense, Proprioception, Vibration Stimulation

1. Introduction

Proprioceptor is positioned inside of muscle, tendon, and joint and plays a critical role in postural reflex, joint stabilization, and motor control. Proprioception is a word that integrates muscle sense and joint position sense, it recognize position inside of a muscle or joint space and contributes in functional joint stability[1]. Joint stability can be classified into structural stability by bone, ligaments, and muscle tissue and functional stability by proprioceptive sense. Proprioceptor has the biggest role in postural balance control[2], reduced proprioceptor sense control can lead to functional instability in joint movements, and sensitivity of it can weaken by aging, disease, high intensity workouts and can be enhanced through low-intensity workouts[3]. Position sense is the ability to estimate position of body segments, is decided by myo-receptor, teno-receptor, joint receptor and skin receptor, functions to adapt to physiological change[4], and plays an important role in daily movements and sports. In[5] have stated that testing joint position sense actively concluded in more effective results than testing it passively[5].

Studying the correlation between postural stability and stimulation of sensory system of the body utilized vibratory stimulus that influences muscles and skins. Vibration means certain up and down movements of a physical value and consists of frequency and amplitude. Trends in regards to vibration in exercise science and pathology in elders follows ongoing research about body composition component and variance factor[6]. Vibratory intervention

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is known to significantly affect proprioception, increase activity of neuromuscular activity and increase range of motion. Since vibration is advantageous due to minimal side effects and no special efforts for learning exercise, there have been numerous ongoing researches since 1990. In[7] have experimented 50Hz vibration per minute and reported strength gain, pain relief compared to control group[7], experimented lower limb angle difference due to vibratory stimulus, and there was significant effect in knee joint angle when vibratory stimulus was applied[8].

There are many sensory stimuli aside from vibratory stimulus. Compared to other stimuli, auditory stimulus is an easily an easily encountered stimulus. In many scenes of daily life, we are exposed to diverse background music without intention, and live under many auditory stimuli such as voice, automobile noise, TV sound. Since auditory stimulus can sedate or stimulate a person, it is widely used in curing disability or psychiatric disorders. Music stimulus can be applied through auditory stimulus, in overall pattern of music; stimulating music stimulates sympathetic nerves to activate motor control while sedative music stimulates parasympathetic nerves to induce stable state. In information input, auditory stimulus provides fast and strong influence, and human sympathetic system is especially sensitive to music stimulus[9]. In[10] have studied the effects of auditory stimulus on change of postural balance in elders, and auditory stimulus not only influence postural change but also has positive effects on static sense[10]. However, according to study by recognition error in auditory stimulus appears to be bigger than that of visual stimulus and visual-auditory stimulus[11].

So far, exercise programs with multi-stimulus addition to enhance position sense have been introduced. There exists lack of study in comparative study about vibratory stimulus and auditory stimulus influencing position sense. Henceforth, this study will examine if vibratory stimulus and auditory stimulus is appropriate for proprioception intervention through comparing position sense of ankle, knee, and hip when vibratory stimulus and auditory stimulus is applied.

2. Materials and Methods

2.1 Subjects

For this research, 40 subjects currently attending S university in Chungcheongnam-do, who has not been treated or received surgery for muscular skeletal condition in ankle, knee, hip joint, who has voluntarily agreed to participate in the research, was selected. Subjects were divided into four groups, and general feature of moderating experimental group and control group is shown in Table 1. Control group measured position sense on ankle, knee, hip difference without any moderation, and experimental group was divided into three groups, one group with ankle, knee, hip measurement with vibratory stimuli, another group with ankle, knee, hip measurement with auditory stimuli, and last group with ankle, knee, hip measurement with auditory and vibratory stimuli.

Table 1. Comparison of average of ankle, knee, hip joint depending on intervention (n=40)

	Auditory group (n=10)	vibration group (n=10)	Auditory, vibration group (n=10)	Control group (n=10)
sex	5/5	5/5	5/5	5/5
age	19.2 ± 0.92	18.8 ± 1.32	18.5± 0.53	21.4±1.26
height (cm)	168.8 ± 11.48	169.0 ± 7.79	170.3± 9.65	169.3±8.25
weight	68.9 ± 13.72	63.4 ± 10.17	71.03± 16.03	62.9±10.35

2.2 Moderating Methods

2.2.1 Auditory Stimulus

For auditory stimulus, light stimulative music was played in headphone in a quiet room which is unaffected from external noise to provide excitative stimulus. As as individuals each subjects differed in level of received stimulus, size of stimulus were individually set in undamaging range.

2.2.2 Vibratory Stimulus

In vibratory stimulus, 10g, a diameter of 1cm, MB-1004V, Micro DC Vibration Motor Korea, 2015 was used and attached for ankle extensors : tibialis anterior muscle and gastrocnemius for ankle measurement, knee extensors: rectus femoris and vastus lateralis for knee measurement, hip extensors: tensor fasciae latae and sartorious for hip measurement. As as individuals each subjects differed in level of received stimulus, size of stimulus were individually set in undamaging range.

2.3 Estimating Methods

Before the research, purpose and procedure of the research was explained to subjects. For minimization cutaneous input through skin, short pants were worn for examination, for minimization of visual compensation, eye patch was worn, and for minimization of movements, femoralis was fixated with belt. To minimalize errors, measuring device, CSMI(CSMi solutions, USA) was utilized to measure plantar flexion angle of an ankle joint, knee joint extension angle, hip joint flexion angle. Evaluation compared average and errors value of target angle and angular reposition.

2.3.1 Measuring Knee Jonit Position Sense

Test was experimented in a sitting position with strating position with knee 90° bent state as 0° for the device, and target angle of 30° extension was applied five times for subjects to remember the angle. After that, participants came back to starting position, took a five-second break, and were asked to reach the previous angle by conjecture and stop.

2.3.2 Measuring Ankle Joint Position Sense

Test was experimented in a prone position, where subjects set 0° of the device in a comfortable position, and target angle plantar flexion of 20° was applied five times for subjects to remember the angle. After that, subjects came back to starting position, took a five-second break, and were asked to reach the previous angle by conjecture and stop.

2.3.3 Measuring Position Sense of Hip Joint

Test was experimented in a supine position, where subjects set 0° of the device in a comfortable position, and target angle hip 95° flexion was applied five times for subjects to remember the angle. After that, subjects came back to starting position, took a five-second break, and were asked to reach the previous angle by conjecture and stop.

2.4 Analysis Methods

Control group with auditory stimulus, and group with vibratory stimulus, and both auditory and vibratory stimulus which resulted in 20° in ankle joint, 60° in knee joint, and 95° in hip joint was compared. Collected data was analyzed through SPSS 22.0 to calculate average and standard deviation of variances. One way ANOVA was used for average analysis, Bonferroni was used for Posterior Analysis. Significance level of all statistics were set as $p<.05$.

3. Result

3.1 Comparison of Average According to Moderation

No significant difference was observed in ankle, knee, and hip joint in groups with auditory stimulus, vibratory input, and both auditory and vibratory input.

3.2 Comparison of Average Error According to Moderation

Measurement of position sense on ankle, knee, hip joint in moderation usage, all three categories showed significant results ($p<.05$). In ankle joint sector, controlled and vibratory stimulus group was 4.26±3.27, 0.38± 0.27 to indicate significance difference, controlled and auditory stimulus group was 4.26 ± 3.27, 8.06 ± 3.26, and in Knee joint Sector, AE of controlled and vibratory stimulus group was 8.40 ± 3.57, 0.63 ± 0.13 to indicate significant difference. Likewise, in hipjoint sector, controlled and vibratory stimulus group were 8.40 ± 3.57, 0.63 ± 0.13 to indicate significant different ($p<0.05$). None of ankle joint, knee joint, and hip joint sector showed significant difference in auditory, vibratory stimulus group. Auditory stimulus group did not show any significant difference ($p>.05$) as shown in Figure1.

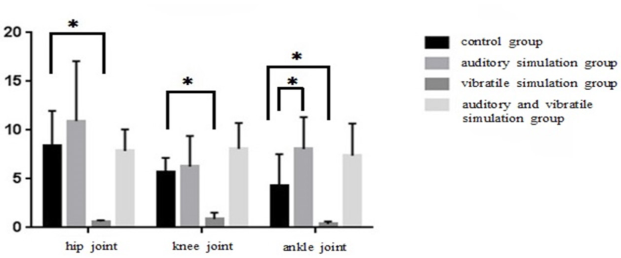

Figure 1. Comparison of average error according to moderation.

4. Discussion

This research examined the effects of auditory and vibratory stimulus on position sense in ankle, knee, hip joint.

When vibratory stimulus was given, significant difference was found in all ankle, knee, hip joint, and when auditory stimulus was given, significant difference was found in ankle joint. Position sense plays critical role in delivering basic information to motor control region such as vestibular sensation and balance region to induce and expedite enhancement of involuntary and voluntary movement. Results of this research indicate that sensory stimulus influence position sense.

Subcategory of sensory stimulus divides into many stimuli such as touch, auditory, and visual sense, and In visual sense, there exists researches providing visual information. In[12] eyes opened condition allowing visual input, position sense's error value increased[12], and13 notes sensory system like vestibular sense, auditory sense, and proprioceptive sense do not develop substantially when one is overly dependent on visual information[13]. This research shows when one is dependent on visual information, it can influence proprioception to in result cause error, and with evaluating position sense in circumstance of given visual stimulus increase error value to influence position error. Due to this reason, visual input was blocked, and position sense was estimated.

Low frequency of vibratory stimulus is known to generate afferent nerve input by stimulating muscle spindle, increase cell numbers of mitochondria, and enhance muscle strength and power, exercise capability while it also can be used in moderating sensory recovery[14]. In[15] studied the correlation between local vibratory application on elbow joints position sense and maximum squeezing strength, and his study concluded that it effects both elbow position sense reposition and maximum squeezing strength[15]. Also,[16] concluded that reason for position sense's error range reduction in condition of given local vibratory stimulus occurred due to viscoelasticity enhancement, increased oxygenation and vasodilation influencing rise of temperature, to enhance proprioception[16]. Along with previous researches, this research shows similar result with significant importance when position sense of ankle, knee, hip joint is measured under influence of low frequency-local vibratory stimulus. It is expected that low frequency of vibratory sense stimulated lower limb's muscle spindle to cause various changes in muscle tissue to reduce position sense error range.

This research used auditory stimulus rather than vibratory stimulus as a moderator. Various methods exist for auditory stimulus research. In[17] studied the effects of auditory stimulus on postural change in elders, it not only caused change in posture but has positive effects on static sense[17]. Studied on postural control under two conditions of blocking visual input and not blocking visual input under auditory stimulus exposure, and all three factors, visual input, non-visual input, auditory stimulus exposure together contributed in influencing postural control, and improved postural control was shown under blocking of visual input with auditory exposure. From these results, significant importance of auditory stimulus on postural change was identified. However, in[12] researches, utilizing visual, auditory, visual-auditory sense to determine correlation between spatial recognition ability utilizing and coordination level of sensory motor movement, recognition error on auditory sense greatly surpassed that of visual and visual-auditory sense[12]. Previous research hypothesized positive effects of proprioception enhancement reducing joint position sense error, concluding correlation between auditory sense with postural change and control, but ankle, knee, hip joint's position sense recognition error was greatly significant under auditory exposure groups, especially under ankle joint. These results are expected to occur for light music inducing recitative stimulus, thus reducing concentration and creating recognition error. Through this research, recognition error increasing under the influence of auditory stimulus exposure, but research on this subject remains unsubstantial. Result of this research implicates the need for further research on vibratory stimulus and position sense.

Limitation of this research is that subjects were healthy male and females, and subject number was limited, thus generalization of all age is not possible. Moreover, regulating vibratory intensity was limited since vibratory stimulus was given through micro DC vibratory motor instead of medical vibratory stimulator.

In this research, it was indicated that under auditory stimulus exposure, error range of joint position angle increased, and under vibratory exposure, error range of joint position angle decreased.

In future research, subjects should include all age, previous patients who experienced ankle, knee, hip joint and regulate vibration intensity to objectively determine the level of vibration intensity has on joint position sense.

5. Conclusion

This research studied on the effect of auditory and vibratory stimulus on ankle, knee, and hip joint's position sense. Vibratory stimulus had significant effect on position sense over auditory stimulus or auditory-vibratory stimulus, and showed most effective results in hip joint. However, position sense error increased under auditory stimulus exposure, most in ankle joint, and error occurred under auditory stimulus exposure and vibratory exposure as well.

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