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Proprioception associated with sub-clinical neck pain

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경미한 경부 통증과 고유수용성 감각

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<요 약>

목적 : 본 연구는 경미한 경부 통증을 가진 대상자의 경부 운동감각과 경부 통증과 기능에 대하여 조사하였다.

방법 : 본 연구의 대상자는 자발적으로 참여한 81명의 (나이 18-30세, 평균 23.2) 건강한 대학생으로 구성되었으며, 측정은 경부운동감각과 통증 및 기능에 대하여 측정하였다. 경부운동감각은 편안히 앉은 자세에서, 경부 후인과 좌우 회전의 중간 관절 범위에서 대상자의 두부에 착용하지 않는 기구를 사용하여 측정하였다. 경부 통증과 기능은 가장 흔히 쓰이는 4가지 설문지를 한국어로 번역하고 문화적으로 적응하는 과정을 거쳐 사용하였다.

결과 : 대상자들을 경부 통증 빈도에 따라 세 집단으로 (통증 없음, 월별, 주별) 구분하였다. 각 집단간에는 4가지 설문지로 조사한 경부통증과 기능에는 차이를 보이지 않았으나, 경부운동감각은 통증 빈도가 높을수록 더 민감하게 나타났다.

결론 : 경부 운동감각은 편안히 앉은 자세에서 경부 후인과 좌 우회전의 중간 관절범위에서 측정하였으며, 경미한 경부 통증 빈도가 높을수록 경부 운동감각은 더 민감하게 나타났다.

중심단어 : neck disability questionnaire, neck proprioception, neck pain

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Ⅰ. Introduction

Neck pain in the general population is a common condition, however, it does not always result in a medical consultation(Bovim et al., 1994; Cote et al., 1998; Grant et al., 1995; Gordon et al., 2002; Lee et al., 2004). Those who have neck symptoms, but who are not yet receiving any treatment are classified as having minor musculoskeletal or 'sub-clinical' neck pain(Grant et al., 1995; Browne et al., 1984). This untreated group is of particular interest with respect to the development/progress of neck pain, as they represent the category intermediate between individuals with no pain and those seeking treatment, so the features which characterize them can be examined as possible targets for early intervention efforts.

In a recent study on sub-clinical neck pain subjects, Lee et al. (2004) reported both sensitization with repeated end-of-range testing and less neck muscle endurance for a sub-clinical pain group compared to normals. One way to further study this sub-clinical pain group is to draw from a population with an anticipated higher incidence of such subjects. Pain in the neck or upper limb is common in computer operators(Grant et al., 1995; Zennaro et al., 2003; Palmer et al., 2001). Due to strong government support for educational computer use in Korean schools, computer use is high in the Korean student population(Jo, 1996; Yang, 2001) with some associated health consequences having been noted. Accordingly, these high frequency computer users represent a population where a relatively high proportion of sub-clinical neck pain might be expected.

To obtain a more complete picture of the characteristics of specific musculoskeletal conditions, other data in addition to range and strength is often gathered. According to the concept of a stabilizing system, proposed by Panjabi (1991) integrity of a neuromusculoskeletal complex depends on three sub-systems; passive structures, active structures and neuromuscular control. The last of these depends on adequate proprioceptive information. In other studies, altered proprioceptive function has been associated with clinical neck disorders (Revel, 1991; Heikkila and Astrom, 1996; Heikkila and Wenngren, 1998; Loudon et al., 1997), but it is not known whether this finding would also be observed with sub-clinical neck pain.

Neck proprioception has received attention from researchers and clinicians as a measure of neck function after injuries arising from both whiplash and work-related causes. Diminished proprioceptive function has been hypothesized to be associated with clinical neck and back pain, and current back rehabilitation programs incorporate elements designed to improve proprioceptive function (Revel et al., 1994; Bullock-Saxton et al., 1993; Janda, 1994; Comerford and Mottram, 2001). Some studies of neck pain disorders have reported poor proprioception as being associated with neck injuries and chronic pain(Revel, 1991; Heikkila and Astrom, 1996; Loudon et al., 1997; Kristjansson et al., 2001; Treleaven et al., 2003), but differences between pain subjects and controls are not always observed(Rix and Bagust, 2001). The proprioception testing procedure employed, typically involves blindfolding subjects to completely obscure vision during head rotation movement(Revel, 1991; Heikkila and Astrom, 1996; Loudon et al., 1997; Kristjansson et al., 2001; Treleaven et al., 2003), and using accuracy of head relocation to a remembered reference position (after an interim active head movement to end of range) as the proprioception measure. To avoid using end-of-range as a defining point when measuring neck movement discrimination ability, the mid range of head movements could be used by setting physical stops to mark the start and end of test movements. In this way, only movements which are alike (ie active movements, to a stop) are used in the test(Laszlo, 1992).

When assessing discrimination abilities, it has been argued that the test should be functional and conducted under normal movement conditions(Laszlo, 1992; Newcomer et al., 2000; Gibson, 1986). Accordingly, an apparatus is requiredto enable the subject to move their neck actively without any equipment attached to their head or other body part with vision unhindered. Rotation and retraction movements are most pertinent, as rotation is the movement most commonly used in exploring the external environment and retraction is the neck movement most affecting posture(Taylor and McCloskey, 1988; Hanten et al., 2000; Rubin et al., 1995).

Such a test needs to be combined with other measures on the same subject group to find which are the most sensitive to early onset of neck pain/dysfunction. Therefore, the purpose of this study was to concurrently investigate neck proprioception, and self-reported pain and disability in a group where some members were likely to be experiencing sub-clinical neck pain.

II. Materials and Methods

A. Subjects

Advertisements placed on notice boards at the College of Rehabilitation Science, Daegu University, South Korea sought subjects over 18 years of age, with no experience of neck, upper back or spinal problems that had resulted in a restriction of normal activity or time-off work. Eighty-one students aged 18 to 30, mean 23.2 (SD ± 3.3) years volunteered. Subjects who had sought medical attention for neck pain and/or related problems within the last 6 months were excluded from participation in the study, as was anyone with any medical condition likely to affect mobility of the cervical spine (eg. ankylosing spondylitis). Ethics approval for the study was obtained, and each subject gave informed consent prior to testing.

B. Procedure

Neck proprioception was measured, defined as the ability to judge the extent of neck retraction and rotation movements using an absolute judgment task. Demographic data were collected followed by neck proprioception test, subjects were questioned regarding any recurrent neck pain/discomfort, then asked to complete Korean translations of the Short Form McGill Pain Questionnaire (SFMPQ)(Melzack, 1987), Functional Rating Index (FRI)(Feise and Michael, 2001), Neck Pain and Disability Scale (NPDS)(Wheeler et al., 1999), and the Neck Disability Index (NDI)(Vernon and Mior , 1991).

An absolute judgment, or single-stimulus identification, procedure was used to obtain the movement-discrimination measure. All movements were performed with vision maintained straight ahead, ensuring that subjects could not see the physical stops at either side. The apparatus used to measure discrimination of neck movements is shown in Fig. 1. A stepper motor, run by a neck version of the Active Movement Extent Discrimination Apparatus (AMEDA) program33 was attached to a height adjustable bar across two fixed poles and connected to a laptop computer. The program allowed the stepper motor shaft to move in and out to five preset positions. There was a fixed rubber knob on the opposite side to the shaft that determined the test starting position for each subject, and a mushroom-shaped contact plate on the end of the shaft that gave only diffuse cheek contact location, to prevent this being used as a distance cue.

The subject sat comfortably on a height-adjustable chair, with their knees at 90 degrees flexion, feet flat on the floor, and their hands placed on their lap. For left rotation, the subject's right cheek was to start in contact with the fixed knob. The movable plate, which was attached to the shaft of the stepper motor, was located in the target range between 25 and 41 degrees of rotation (ie. 25, 29, 33, 37, and 41 degrees

Fig 1. Apparatus and set-up for proprioceptive sensitivity testing. The arrows indicate the moving directions of the shaft driven by the stepper motor. The subject shown is making a left cheek contact with the moveable plate attached to the stepper motor after a left rotation movement. The right cheek was in contact with the fixed black rubber knob to define the start position for the movement. Visual focus was maintained as directly ahead during rotation movements.

were the first to fifth test positions). The subject was required to rotate their neck such that the cheek moved from the fixed to the moveable plate. After each movement the subject was asked to identify which of the five test positions had just been contacted. To familiarize subjects with the test positions, they were first shown the five different locations and given three practices at each with feedback. For testing right rotation, the movable plate was located to the subject's right side, and the test procedure was repeated as for left rotation.

For testing retraction movements, the subject turned such that their forehead (specifically, the glabella) contacted the fixed plate when in their neutral sitting position. The movable plate attached to the shaft was located behind the head in the target range between 1 and 1.8cm (ie. 1.0, 1.2, 1.4, 1.6, and 1.8 cm were the test positions). These retraction test positions had the same physical separation as those used for testing rotation. From their neutral position the subject was asked to pull their head backward and simultaneously tuck their chin in (retract) until the back of their head touched the movable plate. After each movement the subject was asked to identify which of the five test positions had just been contacted. As with rotation, subjects were given three practice runs prior to data collection.

Each of the five testing positions was presented 10 times in random order. Therefore, the subject moved their head a total of 150 times. There were five minute breaks between each of the sessions to minimize the effects of fatigue. With breaks each session took 20 minutes to complete for a total of sixty minutes. Because the range of each test movement set was always in subjects' mid range, it did not cause any stress on their cervical joints and no subject reported experiencing pain as a result of the testing procedure.

Neck pain and disability data were collected after all physical measurements using the Korean translations of the FRI, NPDS, NDI and SFMPQ. The cross-cultural adaptation process described by Beaton et al.(2000) was employed to obtain the Korean language versions of these neck disability questionnaires. Background information was also obtained by structured interview at the end of all physical testing. This included questions about; age, dominant side, hours spent sitting per day, any previous history of neck trauma and related treatment, any recurrent neck pain, and frequency of neck pain.

C. Analysis

Raw scores for the absolute judgments were collated, and data were analysed using Probit analysis, a subroutine in SPSS for Windows, Release 10.05, SPSS (233 Wacker Drive, 11th floor. Chicago, Illinois 60606). The method of Woodworth & Schlosberg (1954) was followed to obtain each subject's JND for both rotations and for retraction, and these were examined in a groups by repeated measures ANOVA. In pilot work separate from the current study, the intra class correlation coefficient(ICC (2,1)), as described by Shrout and Fleiss (1979) was calculated for each Korean version of the neck pain and disability questionnaires, with 40 subjects across two measurement occasions, to assess the reliability of the translated questionnaires. Each translated questionnaire was found to have high reliability (FRI ICC (2,1)=0.86; NPDS ICC (2,1)=0.90; NDI ICC (2,1)=0.90).

Ⅲ. Results

When the histogram of the number of subjects reporting different pain frequencies was plotted, it was found to be trimodal (Fig 2).

Using the modes, the eighty-one subjects were placed into three categories; 22 subjects who reported no experience of neck pain or discomfort, or reported experiencing pain up to six times a year (never/infrequent pain

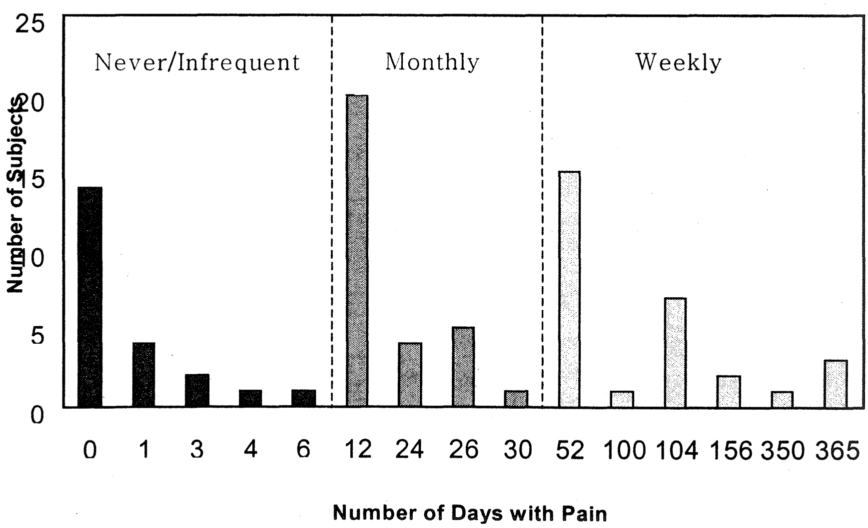

Fig 2. Histogram of the number of subjects at each 'frequency of neck pain' level. The vertical lines define the boundaries of the three categories.

group), 30 subjects who reported experiencing low-level neck pain/discomfort from once a month to three times a month (monthly pain group), and 29 subjects who reported experiencing neck pain/discomfort from at least once a week to daily (weekly pain group). These groups did not differ in age, BMI, daily sitting hours or dominant side (see Table 1). Consistent with findings on gender differences in willingness to report pain,37 there were more females in the gender composition of the groups as pain frequency increased. Accordingly, gender was included as an additional factor in the ANOVAs to determine whether it influenced outcomes (see Table 1).

Gender effects were observed on two measures. Females had significantly greater flexibility overall (F(1, 75)=6.04, p=0.02) and reported higher sensory pain scores on the SFMPQ (F(1, 75)=4.31, p=0.04). Because there were no significant interactions between gender and frequency of pain grouping on any measure, data were pooled across genders in further analyses.

The JND or just-noticeable-difference in movement extent was obtained as a measure of neck movement sensitivity where a lower JND value represents better discrimination. To examine the effects of pain frequency group and movement direction on JNDs, a single rotation JND score was formed from subjects' scores on left and right sides to enable comparison of rotation and retraction. A 3 groups x 2 repeated measures ANOVA was then conducted on the JNDs, using orthogonal contrasts on the between-groups factor to compare, firstly, scores from never/infrequent pain subjects with all those getting pain at least monthly, and secondly, subjects getting neck pain monthly with those experiencing it weekly. Over all movement directions combined, there was a trend towards better discrimination, with lower JNDs, from the combined pain groups compared to the never/infrequent group (F(1, 78)=3.94, p=0.0506). On combined movement directions, subjects experiencing weekly pain were significantly more sensitive than those

Table 1. Mean (standard deviation) for demographic variables for the three groups.

	Never/Infrequent (male=10, female=12)	Monthly (male=9, female=21)	Weekly (male=10, female=19)	*p-value*
Age (years)	*21.1 (2.1)*	*20.7 (1.8)*	*20.6 (1.9)*	*0.70*
BMI (Kg/m²)	*21.8 (2.9)*	*20.7 (2.4)*	*21.4 (2.9)*	*0.37*
Sitting hours (hours per day)	*6.8 (2.1)*	*6.7 (1.8)*	*6.5 (2.6)*	*0.88*
Dominant side	*right*	*right*	*right*	

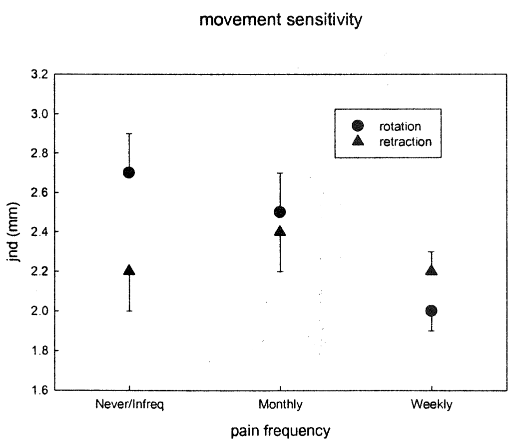

Fig 3. Mean JNDs for rotation and retraction for the three pain frequency groups. Error bars show one standard error.

experiencing monthly pain (F(1, 78)=8.28, p=0.005). Next, when the repeated measures factor of movement direction was examined, a significant interaction emerged (see Figure 3) in which retraction movements were relatively better discriminated than rotation movements by never/infrequent pain subjects, but the JNDs for different directions were not different for those experiencing pain (F(1, 78)=4.84. p=0.03).

Self-report data obtained from the SFMPQ, FRI, NPDS and NDI are presented in Fig 4. In the SFMPQ, monthly and weekly pain subjects scored higher than subjects with never/infrequent pain on the sensory, affective and usual pain subscales (F(2, 78)=19.04 p<0.01 F(2, 78)=10.43, p<0.01; F(2, 78)=28.79, p<0.01 respectively). Subjects with monthly and weekly pain did not differ on any of those subscales. With the neck disability questionnaires, FRI, NPDS and NDI, the pattern was similar to the SFMPQ. Monthly and weekly pain subjects scored significantly higher than subjects with never/infrequent pain (F(2, 78)=43.78, p=<0.01; F(2, 78)=20.00, p<0.01; F(2, 78)=31.83, p<0.01), and no difference was found between monthly and weekly pain subjects.

Ⅳ. Discussion

Young computer using adults who reported experiencing sub-clinical neck pain more frequently reported more intense pain, and scored higher on disability questionnaires than those with less frequent pain occurrence. In addition, the group experiencing neck pain most frequently demonstrated superior movement discrimination.

Some of these findings replicate previous ones. Gender effects where in females have greater neck flexibility, and sensory pain scores have been observed by others(Ferrario et al., 2002; McClure et al., 1998; Chen et al., 1999; Holdcrof and Power, 2003).

On scoring the responses of self-report questionnaires in the current study, subjects complaining of monthly pain were in general intermediate between the never/infrequent pain and weekly pain groups. However, on

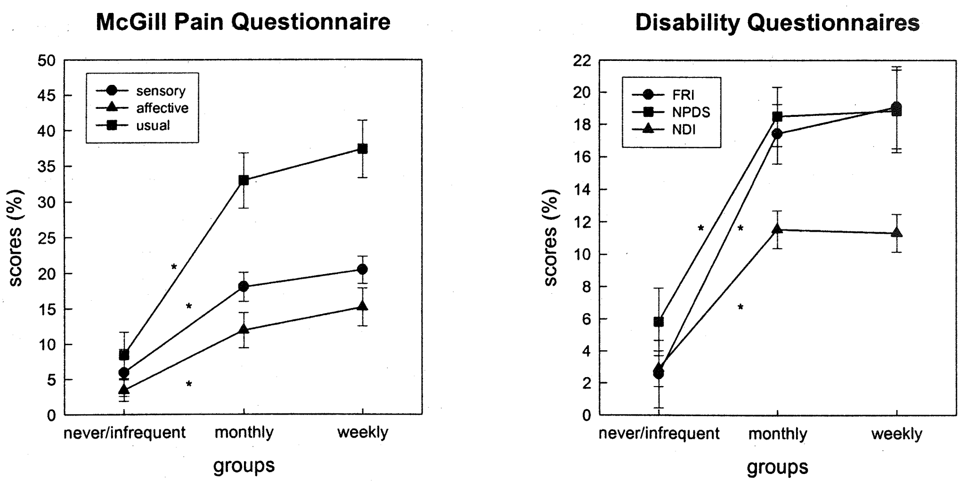

Fig 4. Mean scores for the three groups on the questionnaires. Asterisks represent differences between points which were statistically significant at the level of p<0.05. All scores were converted to percentages of the maximum possible on each scale.

the SFMPQ, monthly pain subjects scored similarly to those with weekly pain on their 'usual pain' subscale, but on the sensory and affective subscales rated their pain less than weekly pain subjects. The rated intensity of usual pain varied little between frequent and infrequent subjects, but it was the quality of pain and distress which became more severe for more frequent (weekly) pain subjects than for less frequent (monthly) pain subjects.

All disability questionnaires in the current study discriminated between never/infrequent and frequent neck pain subjects. The trend of responses on the disability questionnaires was similar to the rated intensity of their usual pain, in that the monthly and weekly neck pain groups scored at a similar level on the disability questionnaires. These self-report data suggest that at the point when people have neck pain more frequently than monthly, they become more distressed and aware of their pain. This aspect of pain response can be seen as consistent with clinical neck pain studies, where a high level of psychological distress is correlated with being more likely to use health care services(Von Korff et al., 1991; Leclerc et al., 1999). A prospective longitudinal study of this sub-clinical neck pain group is needed, however the present data suggest that the 'neck pain more often than monthly' response may be a yellow flag identifying this group as 'at risk' of developing a degree of pain and disability that may cause them to seek treatment. Accordingly, this group may benefit from early intervention.

The more frequent neck pain group also showed more sensitive discrimination for extent of mid-range rotation movement, whilst there was no difference in discrimination scores with retraction movement compared to less frequent pain groups. Better, rather than worse, performance on a proprioception task by pain subjects has been noted elsewhere: for example researchers have also reported a higher level of back movement sensitivity in subjects with chronic low back pain and idiopathic scoliosis compared to normal subjects(Newcomer et al., 2000; Herman et al., 1985; Barrack et al., 1988; Newcomer et al., 2000; Field et al., 1991). There are two possible accounts of these findings. It might be suggested that nociceptive input enhances sensitivity to mechanoreceptor input, thereby providing additional information on proprioception for use in movement control, rather than interfering with it(Torebjork et al., 1992). Secondly, it may be that the heightened proprioceptive sensitivity precedes the onset of pain, and is part of a cluster of predisposing factors for more frequently-occurring pain.

Other studies have reported impaired proprioception in pain subjects, which would seem to conflict with the findings here. However, consideration of the different methods used for testing discrimination ability may explain the discrepancy. Mid-range neck movement between two physical stops was used to define the discrimination test in the current study, whereas other studies have used end-of-range as their defining position for starting the discrimination test, with the endpoint for the recall movement specified as an absolute position in space. These studies have reported that subjects with neck pain demonstrate consistent 'overshooting' at the end position in their tests comparing to normal subjects(Revel, 1991; Heikkila and Astrom, 1996; Heikkila and Wenngren, 1998; Loudon et al., 1997; Treleaven et al., 2003). This trend was also reported in a low back pain study(Lam et al., 1999). Walsh et al. (1971) and Bevan et al. (1994) have demonstrated that distance and location coding are closely inter-related in the movement control system.

If the start position becomes closer to the recall target location through sensitization, the end-of-range relocation will tend to be an overshoot as subjects try to reproduce the criterion distance as well as location.

Therefore, using end of range as the starting position for the relocation movement may bring a confounding factor into the test procedure if there are systematic changes in end of range which occur during testing. In subjects not being treated for neck pain but who have experienced recurrent neck pain, moving more than once to end of flexion or extension range induced a sensitization effect, with a more limited range resulting on the second attempt(Lee et al., 2004). Because any reference movement generates both distance and location information, memory for the movement is influenced by both types of information(Walsh et al., 1979; Bevan et al., 1994). By this hypothesis, the obtained results using end-of-range as a defining position for the test could be expected to show systematic overshooting with neck pain disorder subjects. Indeed, this overshooting has been observed in several studies suggesting that using 'end-of-range' as a defining point for neck pain subjects means using a point that shifts due to sensitization(Revel, 1991; Heikkila and Astrom, 1996; Heikkila and Wenngren, 1998; Loudon et al., 1997; Treleaven et al., 2003).

In conclusion, subjects who experienced pain more often than monthly were identified by the SFMPQ on all attributes (sensory, affective, and usual pain) and by three disability questionnaires (FRI, NPDS, NPI) as significantly different from the never/infrequent pain subjects. Further, sensitivity for extent-of-movement was significantly better for the weekly pain group compared to the monthly neck pain group.

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