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Influence of Water Exercise and Land Stretching on Salivary Cortisol Concentrations and Anxiety in Chronic Low Back Pain Patients

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Abstract Land stretching exercises are common exercise therapy for low back pain (LBP) patients. However, recently, water exercise became a popular rehabilitation for LBP patients, and many studies have reported the physical benefits of water exercise. This study compared the psychological and endocrinogical effects of water exercise and land stretching by measuring salivary cortisol concentration and anxiety in chronic LBP patients. Seven volunteers (4 female and 3 male, mean age: 61.9 ± 11.8 yrs) who suffered from chronic LBP (pain duration: 4.5 ± 1.3 yrs) participated in the sessions of water exercise and land stretching programs (90 minutes) on different days. The land stretching program consisted mainly of stretching, and the water exercise program contained not only stretching, but also walking, jogging, muscle strengthening, swimming and relaxation. After both exercise programs, the subjective pain scores of the patients showed a significant decrease. Salivary cortisol concentrations were also significantly decreased during pre- to post-90 minute water exercise. ($P<0.05$). With land stretching, salivary cortisol concentrations also decreased significantly ($P<0.05$). State anxiety decreased significantly ($P<0.05$) after both water exercise and land stretching compared with pre-exercise scores ($P<0.05$), though no significant changes were found in the patients' trait anxiety scores. No significant correlation was found between salivary cortisol concentrations and state anxiety with water exercise and land stretching. The findings of the present study suggested both exercises showed similar tendencies, and had decreased salivary cortisol level and state anxiety. *J Physiol Anthropol 19 (4): 175-180, 2000* http://www.jstage.jst.go.jp/en/

Key words: water exercise, land stretching, chronic low back pain, salivary cortisol, anxiety

Introduction

Land stretching exercises such as Williams (Williams, 1955) or McKenzie's (McKenzie, 1981) exercises are common exercise therapies for low back pain (LBP) patients. However, recently, water exercise has become a popular rehabilitation for people who suffer from chronic LBP (Langridge and Phillips, 1988; Smit and Harrison, 1991; LeFort and Hannah, 1994). By utilizing the characteristics of water (buoyancy, water pressure and water drag, etc.), water exercise could be an effective training for improving physical fitness in the elderly or those who are physically unfit. The buoyancy of the water means that exercise in water is less physically demanding than exercise on land. Some studies reported the physical benefits of exercise in water for LBP patients, such as significant decreases in pain, disability (Langridge and Phillips, 1988; LeFort and Hannah, 1994) and improvements in flexibility (Smit and Harrison, 1991). However, few studies have reported the psychological benefits of water exercise for LBP patients.

Psychological factors play a part in chronic pain such as LBP (McCracken et al., 1996), and previous studies have reported positive relationships between chronic LBP and anxiety (Garron and Leavitt, 1979; Franz et al., 1986; Murphy et al., 1997). Many studies have investigated the benefits of exercise on psychological moods, and moderate exercise is thought to have a positive effect in decreasing negative moods such as anxiety or depression (Moses et al., 1988; Steptoe and Bolton, 1988). Sugano et al. (1999) investigated the possible relationships of the psychological benefits of water exercise for LBP patients, and found that after 8 weeks of water exercise, LBP patients showed a significant decrease in anxiety along with increases in relaxation with less pain. Some studies reported the positive effects of a single session of land exercise for psychological changes (Steptoe and Bolton, 1988; Steptoe and Cox, 1988; Brown, 1990), however, the effect of a single session of water exercise on psychological changes has not been reported. From the findings of Sugano et al. (1999), we assumed that anxiety is one of the factors related to pain for chronic LBP patients, and since water exercise is beneficial by decreasing pain, this suggested that it would also be beneficial to decrease physical and psychological stress.

Stress hormones such as cortisol and catecholamine

were utilized to assess the level of physiological or psychological stress (Kindermann et al., 1982; Guezennec et al., 1986; Filaire et al., 1996; Jin, 1992). Some studies have reported that intense and moderate physical exercise stimulated the secretion of cortisol in blood (Kindermann et al., 1982; Guezennec et al., 1986) or in saliva (Filaire et al., 1996). In addition, Jin (1992) reported that salivary cortisol levels dropped after low intensity exercise in connection with decreasing anxiety, and many studies have suggested a relationship between anxiety and salivary cortisol (Lader, 1983; Rudolph and McAuley, 1998; Breier, 1989; Eck et al., 1996). From these studies, we examined the influences of a session of water exercise on anxiety and hormonal response by measuring salivary cortisol concentrations, and their relationships. To assess the physiological and psychological benefits of water exercise, land stretching, which was also popular exercise rehabilitation of LBP patients, was conducted in this study.

The purpose of the present study was to assess the influence of a single session of water exercise or land stretching on salivary cortisol concentrations and anxiety in chronic LBP patients.

Methods

Participants

Seven elderly patients (4 female, 3 male) participated in the sessions of the water exercise and land stretching programs. Their mean age was 61.9 ± 11.8 yrs, and they all suffered from chronic myofasicial LBP, and LBP symptoms of participants were relatively low-grade according to the pain scores (Table 1), and participants could cope with most living activities. The mean duration of LBP was 4.5 ± 1.3 yrs. Patients consulted with a medical doctor and had permission to participate in the exercise programs. Their mean height was 148.4 ± 2.5 cm for females and 160.7 ± 7.9 cm for males, and their mean body weights were 47.9 ± 2.5 kg and 61.2 ± 1.9 kg, respectively. They were all retired from working, and were not accustomed to daily exercise.

Protocol

Water exercise program: The water exercise program was based on the concept of the Aqua-exercise proposed by Nomura (1986). It contained various kinds of exercises not only swimming but also walking, jogging, stretching, muscle strengthening and relaxation. The program consisted of stretching on land, walking and jogging in the water, stretching in the water, muscle strengthening in the water, and swimming and relaxation. The session was held for 90 minutes. Water temperature was kept around 30°C. Participants were immersed in water from the waist to the ensiform level, and the faces were not immersed in water throughout the session (Fig. 1).

Land stretching program: The land stretching program mainly consisted of Williams's (Williams, 1955) and McKenzie's (McKenzie, 1981) common stretching exercises aimed at improving the range of lumbar motion for low back pain patients. The session was held for 90 minutes (Fig. 1).

Participants were engaged in the water exercise program first, then they participated in the land stretching program on a different day.

Disability measurement

Perceived functional impairment was measured using the Oswestry low back pain disability questionnaire (ODQ) which was developed by Fairbank et al. (1980) prior to the beginning of the exercise programs. This contains 10 sections on different activities of daily living relevant to the

Table 1 VAS & ODQ scores of the patients

Variable	Water exercise	Land stretching	P
ODQ (%) at outset	6.9 ± 2.3	7.0 ± 2.7	N.S.
VAS (mm) before exercise	21.3 ± 8.1	13.4 ± 8.6	N.S.
VAS (mm) after exercise	6.1 ± 3.2	3.7 ± 1.9	N.S.

Values are mean ± SE. $P<0.05$.

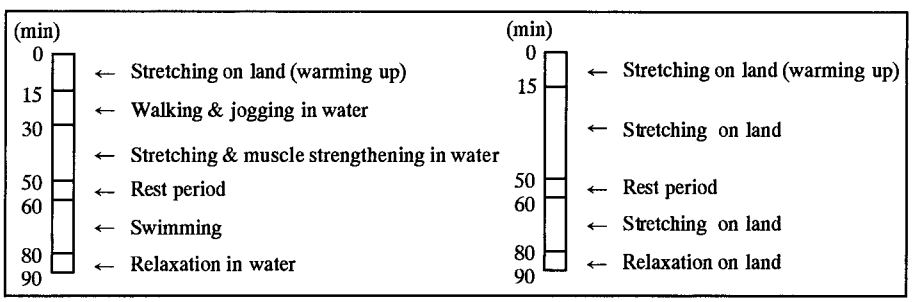

Fig. 1 Contents of water and land exercise programs.

individual with LBP. Scores range from 0 to 100% disability. A two-day test-retest reliability of r=0.99 with high internal consistency has been reported (Fairbank et al., 1980). A number of studies have reported that scores are related to improvement in LBP patients during rehabilitation (Fairbank et al., 1980; LeFort and Hannah, 1994).

Pain measurement

The visual analogue scale (VAS) was used to assess the subjective experience of pain (Huskisson, 1974) before and after exercise. VAS is a unidimensional pain measure in which patients describe their pain by placing a mark at the appropriate distance along a 10 cm line between the endpoints "no pain" and "worst possible pain". The position of the mark has been shown to provide a reliable and valid assessment that is sensitive to variations in pain intensity (McDowell and Newell, 1987).

Anxiety measurement

The 20-item state portion of the State/Trait Anxiety Inventory (STAI) developed by Spielberger et al. (1970) and translated into Japanese by Nakazato and Mizoguchi (1982) was used as a measure of anxiety. Its internal consistency is high, and the Cronbach α was 0.92 for state anxiety items and 0.71 for trait anxiety items.

Salivary cortisol measurement

All salivary samples were taken at 18:30 and 20:00, which corresponded to pre- and post-exercise time on a different day, respectively. Subjects rested in a sitting position for 15 minutes before saliva samples were taken. Subjects spat into a sterile graduated container until 5 ml of salivary had been collected. The saturated roll was placed in a capped plastic vial ("Salivette", Sarstedt, Rommelsdorf, Germany). They were centrifuged for 5 minutes at 2,500 rpm, and stored frozen at − 20°C before use. The salivary cortisol concentrations were determined by radioimmunoassay. All subjects were told not to do intense exercise on the measurement days, and prohibited from food intake 3 hours before the measurement.

Data analysis

Within the group, comparison was carried out using the non-parametric Wilcoxon signed rank test on the paired samples. Statistical significance was set at $P<0.05$.

Results

At the outset of water exercise and land stretching, no significant differences were observed with ODQ (disability variables) (Table 1). The mean VAS (subjective pain) score was higher at the time of water exercise compared with that of land stretching (Table 1), although differences were not significant. After water exercise and land stretching, the VAS scores decreased (Fig. 2).

A significant difference was found in the salivary cortisol concentration from 4.1 ± 0.6 to 2.7 ± 0.5 nmol·l^{-1} pre- to post-water exercise ($P<0.05$). After land stretching, the salivary cortisol concentration was also significantly decreased from 3.9 ± 0.5 to 2.9 ± 0.4 nmol·l^{-1} ($P<0.05$) (Fig. 3). State anxiety was also significantly decreased from 31.1 ± 2.8 to 29.0 ± 2.6 ($P<0.05$). In addition, trait anxiety decreased from 37.4 ± 4.5 to 35.1 ± 3.2 after water exercise, although the differences was not significant (Figs. 4-1, 4-2). At land stretching, the mean scores of state and trait anxiety were lower than those for water exercise, however, state anxiety also decreased significantly (Fig. 4-1) from 27.1 ± 2.3 to 25.0 ± 2.2 ($P<0.05$). Trait anxiety showed no significant changes pre- to post-land stretching (from 35.9 ± 2.9 to 34.1 ± 2.6, Fig. 4-2).

Table 2 shows percentage changes of variables after each exercise program, and no significant differences were found between the groups. No correlation was found between percentage changes of anxiety and salivary cortisol concentrations with land and water exercises, and Fig. 5 shows the percentage changes in state anxiety and salivary cortisol concentrations with land and water exercise.

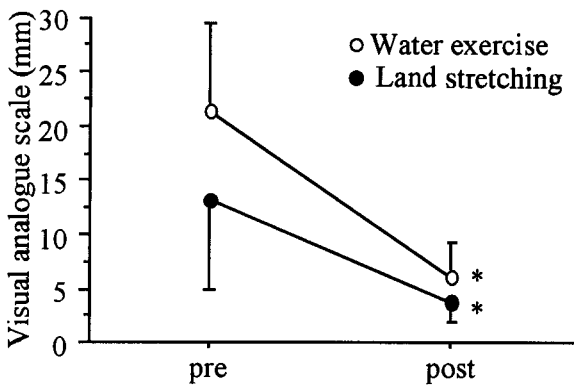

Fig. 2 Changes in VAS score pre- to post-exercise. Values are mean ± SE. *p<0.05.

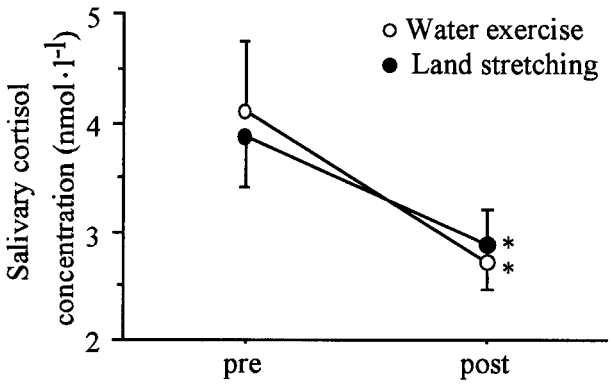

Fig. 3 Changes of salivary cortisol concentration pre- to post-exercise. Values are mean ± SE. *p<0.05.

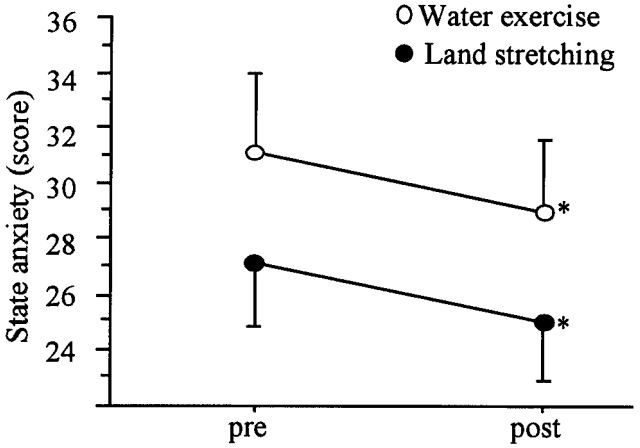

Fig. 4-1 Changes in state anxiety score pre- to post-exercise. Values are mean ± SE. *p<0.05.

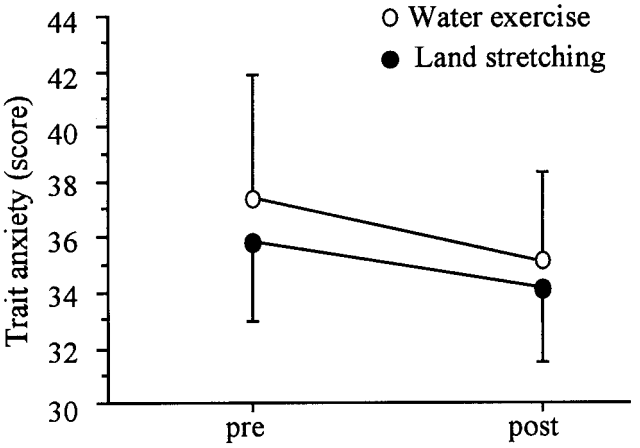

Fig. 4-2 Changes in trait anxiety score pre- to post-exercise. Values are mean ± SE.

Table 2 Percent changes of variables after exercises

Variable	%change at water exercise	%change at land stretching	P
VAS	66.7 ± 17.4	65.0 ± 8.3	N.S.
State anxiety	6.5 ± 3.0	7.6 ± 2.5	N.S.
Trait anixety	36.5 ± 4.5	34.9 ± 2.9	N.S.
Salivary cortisol concentration	34.3 ± 6.7	24.3 ± 8.3	N.S.

Values are mean ± SE. %change show (pre-post)/pre values*100.

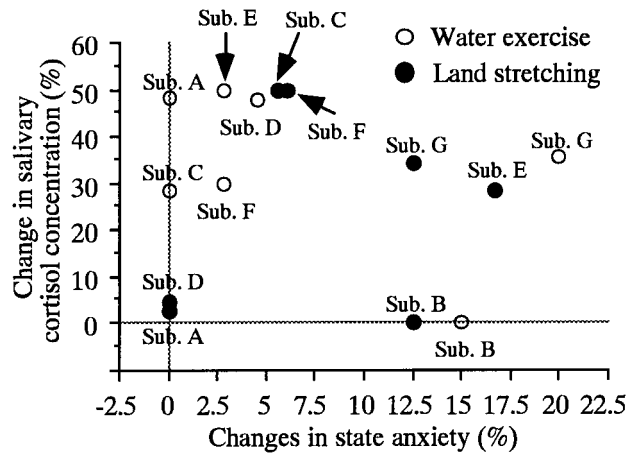

Fig. 5 Correlation of changes of salivary cortisol level and state anxiety with exercises. %changes show (pre-post)/pre value*100.

Discussion

The relationship between exercise, anxiety and salivary cortisol concentrations

It has been widely accepted in previous studies that various forms of physical exercise can enhance positive mood and decrease negative moods such as anxiety and depression. In the present study, state anxiety was significantly decreased (P<0.05) with exercise. However, trait anxiety showed no significant changes. Folkins and Sime (1981) reported that fitness training is associated with improvement in anxiety, an effect which is more pronounced in subjects who are more distressed or physically unfit at the outset. In the present study, patients were restricted in their daily living because of chronic LBP, and after the participation in exercise, subjects showed a significant decrease in pain and state anxiety (P<0.05). Brown (1990) reported that there are associations between exercise and anxiety (Steptoe and Bolton, 1988; Steptoe and Cox, 1988), and suggested that theoretically, state anxiety would change in response to a single exercise session, whereas involvement in extended exercise might alter trait anxiety. The findings of the present study suggested that a single session of water exercise would decrease state anxiety the similar to land stretching, as reported previously (Steptoe and Bolton, 1988; Steptoe and Cox, 1988; Brown, 1990).

Stress hormones such as cortisol are secreted during intense or moderate physical exercise (Kindermann et al., 1982; Guezennec et al., 1986; Filaire et al., 1996), and different types of exercise such as swimming and handball will influence the concentration of salivary cortisol (Filaire et al., 1996). Filaire et al. (1996) reported that salivary cortisol concentration during water exercise was lower

than that during land exercise. From this finding, it was suggested that exercises will increase the concentrations of salivary cortisol, and the salivary cortisol concentrations during water exercise will increase moderately compared with that of land stretching because of the differences in stress induced by both water and land exercises. However, in the present study, the score of state anxiety and salivary cortisol concentrations were similarly significantly decreased ($P<0.05$) with water exercise and land stretching.

The land stretching program in the present study mainly consisted of stretching exercises, and Jin (1992) reported that after low intensity exercise, such as Tai Chi and brisk walking (6 km/h), salivary cortisol levels dropped significantly and the mood states were improved. In the present study, the salivary cortisol concentration and anxiety were also decreased, and it was suggested that the exercise intensity of water exercise and the land stretching program, conducted in the present study were low, and this is one of the reasons for decreasing salivary cortisol levels and improving anxiety.

Filaire et al. (1996) reported that salivary cortisol concentrations were significantly increased after land exercise (handball) which did not appear with swimming and sedentary controls, and considered that the respective hemodynamic conditions of swimming and handball differed because of the posture of the body. During swimming, part of the blood volume is shifted from the vessels of the leg to the upper body (Nielsen et al., 1984), and the body position and water pressure will affect the secretion of hormones (Guezennec et al., 1986). In the present study, salivary cortisol concentrations were significantly decreased after both water exercise and land stretching ($P<0.05$). Since most of the participants were not well-trained swimmers, they exercised with their heads out of the water, therefore, we could expect minimal consequences of the hemodynamic effect because of the differences in body posture on the hormonal responses during water exercise. It was considered that the buoyancy of water could possibly influence the secretion of salivary cortisol. Since buoyancy affects the patients' body, anti-gravity muscles would be released and make the patients feel less physical burden and lower back pain, thus enabling them to exercise in water with less stress than exercising on land. The characteristics of water might be a factor in decreasing the concentration of salivary cortisol as a response to exercise in water. The present findings showed that the percentage changes in salivary cortisol concentration after water exercise were 10% higher than mean value compared with land stretching.

With water exercise, by utilizing the characteristics of water, LBP patients could move their bodies more easily compared with exercise on land. Therefore, the water exercise program could include various kinds of exercise such as walking, jogging, stretching, muscle strengthening, swimming and relaxation in the present study. There were many causes of LBP in the LBP patients and they not only needed to stretch muscles and joints, but also strengthen the abdominal and back muscles, or sometimes they needed to lose body weight in order to decrease the stress on the spine. If the exercise program which includes many different kinds of exercise has the effect of decreasing pain, state anxiety and bodily stress, it was suggested that the exercise programs would be useful to improve their chronic LBP.

The relationship between anxiety and salivary cortisol concentration

The relationship between salivary cortisol concentration and anxiety have shown that increased cortisol levels are associated with increases in anxiety (Lader, 1983; Rudolph and McAuley, 1998). Furthermore, Breier (1989) reported that there was good evidence that stress and anxiety are related to increased resting levels of plasma cortisol. Eck et al. (1996) also reported that anxiety showed small but statistically significant positive associations with cortisol concentration.

In the present study, salivary cortisol level and state anxiety were decreased significantly. However, there was no significant correlation between salivary cortisol concentrations and state anxiety during both exercise programs. On an individual level, subject A showed no changes in state anxiety, and showed decreased salivary cortisol concentration after both forms of exercise. However, subject B showed decreases in state anxiety scores with both exercise programs, although, there was no change in salivary cortisol concentrations. We also examined the possibility of the ceiling and floor effects by excepting only one set of mesurements, however, no significant difference was found. Salivary cortisol concentration and state and trait anxiety varied much more individually, and this might explain the reason why the correlation values were not significant. McCartan et al. (1996) reported that salivary cortisol levels and anxiety were not well-correlated, because individual anxiety would clearly vary from person to person. However, their study was actually concerned with the relationships between trait anxiety and salivary cortisol. Therefore, further studies will need to discuss the relationships between state anxiety and salivary cortisol.

In conclusion, the present findings indicated that water exercise and land stretching had the effect of decreasing the level of salivary cortisol and state anxiety.

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