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Original Article

The Effects of Visual Feedback and Verbal Encouragement on Abdominal Muscles Endurance Tests

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ABSTRACT

Background: Abdominal muscles are one of the most important components that provide trunk stability. It has been reported that abdominal muscles endurance can be decreased in patients with low back pain. Tests that can be used for the assessment of abdominal muscles endurance; include supine isometric chest raise (SICR) and supine double straight-leg raise (SDSLR) tests. The aim of this study is to investigate the effects of visual feedback and verbal encouragement on endurance tests of deep abdominal muscles.
Methods: In this two-factor mixed design study, a convenient sample of 40 asymptomatic (healthy) participants (20 males and females each) aged between 20-35 years was selected. Each subject performed the SICR and SDSLR tests under 4 conditions: no feedback, visual feedback, verbal encouragement, and combined visual feedback and verbal encouragement. The tests were terminated when the subject was no longer able to maintain a position. Furthermore, each test was repeated twice with 5 min interval and the average time was recorded for analysis.
Results: Endurance test time was improved significantly when 2 types of feedback were given during the tests ($P<0.01$). However, combined visual feedback and verbal encouragement had superior effect on endurance test time compared to visual feedback or verbal encouragement alone ($P=0.01$).
Conclusion: The incorporation of verbal encouragement and visual feedback is an important factor in improving holding time during endurance tasks. This may have important implications on endurance training and rehabilitation programmes of abdominal muscles.

Introduction

Muscle endurance can be defined as the ability to produce and maintain a task over a period of time [1]. Deep abdominal muscles are one of the most important components that provide trunk stability by increasing intra-abdominal pressure and thoracolumbar fascia tension [2]. Poor coordination of the lumbopelvic muscles affects posture and the synergic activation of respiratory muscles in healthy individuals. Studies haveshown that prescribing specific exercises for the lumbar-pelvic muscles have positive respiratory effects in obese men [3]. In addition, the transverse abdominis (TrA) and the posterior part of the internal oblique (IO) muscles have been considered as a part of deep stabilizer muscles. These muscles provide stability for the lumbar spine during daily functions [4-8]. It has been reported that

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activation of these muscles has a protective role for the lumbar spine [9]. Several studies have indicated that the activation pattern of the diaphragm, pelvic floor and deep abdominal muscles play a critical role in lumbar stability [5, 6, 10-14]. According to the literature, abdominal muscles endurance could be an important factor for preventing lowerback pain in healthy subjects [2, 15].

There are many tests that are commonly used in general practice and research for the evaluation or increased endurance of abdominal muscles e.g. supine double straight leg raise (SDSLR), supine isometric chest raise (SICR), flexion rotation and leg lowering test [1, 16-18]. It seems that these tests are easy to perform, cost effective, and no special equipment are needed to accomplish them [19].

Feedback can be considered as specific information provided to a learner to promote reflection on performance. It emphasises on both what was done and what the consequences of the action might be. The ultimate objective is to help learners organize their own objectives and criticize their own performance [20]. Visual feedback and verbal encouragement are two common types of feedbacks that are frequently used for the improvement of performance [21].It has been shown that verbal encouragement can be an effective factor to inhibit the signals from supra-spinal pathways [22]. Therefore, verbal encouragement can reduce the effect of fatigue by enhancing the recruitment of motor units [23, 24]. Previous studies revealed that visual feedback can have a positive effect on performance by increasing the effort of patients as well as decreasing error during rehabilitation programs [25-30]. Furthermore, visual feedbackhas been found to increase torque output in knee flexor and extensor muscles [31, 32]. Some studies have indicated that encouragement can increase peak torque by up to 5%, while others have found no significant change in peak torque for quadriceps and hamstring muscles in healthy individuals [21, 33]. It seems that visual/verbal feedback usage can enhance deep muscle performance according [21, 33]. Before testing this hypothesis the effect of visual/verbal feedback on the lower back of patients in healthy individuals needs to be investigated. This will make it possible to test the effect of feedback on deep local muscles in patients with low back pain in future studies. To the best of the authors' knowledge, there have beenno study to evaluate the effects of feedback on abdominal muscles endurance tests in healthy individuals. The results showed that recognition of gender differences in the prevalence of movement impairments is important for improving examination and intervention inpeople with LBP. Therefore, it is necessary to determine the effect of gender on abdominal muscles endurance [34]. The main purpose of the present study is to investigate the effects of visual feedback and verbal encouragement on endurance tests of deep abdominal muscles. We hypothesized that both visual feedback and verbal encouragement can increase the holding time of abdominal muscles endurance tests in asymptomatic participants.

Methods

A convenient sample of 40 asymptomatic (healthy) participants [20 males and females each) aged between 20-35 years was undertaken for this two-factor mixed design study. Participants were recruited from the student population through telephone contact and flyers. The study was performed in the Biomechanics Laboratory of the Physical Therapy Department at the University of Social Welfare and Rehabilitation Sciences, Tehran, Iran. Healthy students were included in this study while students with any history of LBP for the past 6 months; spinal surgery, spinal or pelvic fracture, history of hospitalization for severe trauma; history of osteoarthritis or fracture of the lower extremities, and history of any systemic disease such as arthritis or tuberculosis were excluded from the study. All participants signed a written informed consent form approved by the Ethics Committee of the University of Social Welfare and Rehabilitation Sciences(no: 94-801-T-1-892).

In order to evaluate abdominal muscle endurance, supine isometric chest raise and supine double straight-leg raise tests were used since they evaluate the upper and lower abdominal muscles performance, respectively. These muscles play a very important role in preventing low back pain.

The participant's position was supine on a treatment table with hands crossed on his/her chest. The knees and hips were at 90° flexion. The participant was instructed to lift neck and upper trunk from the table and hold this position as long as possible [16, 35]. Time was measured in seconds. The test was terminated when the participant reported that there was no ability to maintain this position.

The participant's hips were extended, with hands lying beside his/her trunk in the supine position. Afterwards, the participant was asked to raise both legs from the treatment table at about 20° and hold this position as long as possible without any tilting in the pelvis. During the test, the pelvic tilt was monitored by a physiotherapist. Time was recorded in seconds and the test was terminated when the participant was no longer able to maintain knee clearance [16]. A previous study showed that the lumbar and abdominal trunk muscles endurance tests appeared to be reliable and valid measures in office workers with subacute low back pain [36].

Each test was performed under four conditions in random order to reduce the effect of fatigue on the results of this sudy. The conditions were as follows: Performing the tests without feedback; with visual feedback; verbal encuragement; and combined visual feedback and verbal encouragement. Visual feedback was provided by allowing the participants to observe the screen ofa digital chronometer. Furthermore, verbal encouragement consisted of the physiotherapist commanding in a loud voice, "*hold, hold, hold*..." to encourage the participants to maintain the testing position as long as possible.

All clinical endurance tests were applied in a random order for the participants. In addition, each test was repeated twice with 5 min-intervals and the average time was recorded for analysis. There was a 10-min interval between two conditions. Prior to the conduct of the study, all participants attended a familiarization session and the procedures of the investigation were completely explained

by a physiotherapist. The familiarization period lasted 5 min in which the examiner described the tests and performed the positions once.

Statistical analyses were performed with Statistical Package for Social Sciences (SPSSVersion 17.0, Chicago, IL)). Prior to statistical analyses, the Kolmogorov-Smirnov (K-S) test was used to assess the normality of data distribution. Endurance time was analyzed using a 2 × 4 mixed ANOVA model to determine the main effects and interactions of the four factors/conditions (No feedback, VF, VE, VF plus VE) by gender (male, female). P-value of 0.05 was chosen. For determining sample size, alpha and beta wereset at 0.05 and 0.20, respectively.

Results

Demographic characteristics based on age, height and weight are presented in Table 1.

As Table 2 indicates, no significant interaction was found between feedback and gender for SICR (P=0.47) and SDSLR (P=0.82). Simple main effect analysis showed that SICR (F=11.55, P<0.01) and SDSLR (F=19.89, P<0.01) were affected by feedback. In addition, simple main effect analysis showed that SICR (F=0.03, P=0.76) and SDSLR (F=0.00, P=0.95) were not affected by gender.

The comparison between the effects of the four test conditions with each other was conducted atthe time of SICR test (Table 3). As shownin Table 3, visual feedback alone, verbal encouragement alone and both combined had a superior effect onSICR and SDSLR compared to no feedback (P<0.01) (Tables 3 and 4). Indeed, combined visual feedback and verbal encouragement had a superior effect on SICR and SDSLR compared to visual feedback or verbal encouragement alone (P<0.05) (Tables 3 and 4).

Discussion

The purpose of the current study was to investigate the effects of visual feedback and verbal encouragement on endurance tests of deep abdominal muscles. Overall, the results of the study showed that gender did not affect the endurance time but the endurance time changed among the four types of feedback vis-a-vis: no feedback, VF, VE, and VE plus VF . In addition, the results of this study indicated that different types of feedback can improve the time of SICR and SDSLR tests in asymptomaic participants. Some previous studies showed different results about the effects of visual feedback and verbal encouragements on the strength and peak torque of various muscles [21, 27, 37, 38]. However, to the best of the authors' knowledge, no study has assessed the effects of these feedbacks on the endurance of deep abdominal muscles.

Kanemura et al. stated that visual feedback can enhance the excitement level of the cerebral cortex. This results in a considerable increase in launching frequency as well as the number of motor units [39]. Therefore, it seems

Table 1: Participants' baseline demographic characteristics

Asymptomatic participants	n	Age (Year) (Mean±SD[a])	Weight (Kg) (Mean±SD[a])	Height (cm) (Mean±SD[a])
Male	20	24.4 (3.43)	78.10 (14.20)	179.35 (5.15)
Female	20	26.15 (3.66)	61.50 (11.60)	164.20 (5.80)
Total	40	25.27 (3.61)	69.8 (15.31)	171.77 (9.39)

[a]SD: Standard deviation; [b]BMI: Body mass index

Table 2: Summary of analysis of variance for endurance time

Independent variable	F		P value	
	SICR[a]	SDSLR[b]	SICR[a]	SDSLR[b]
Feedback	11.55	19.89	P<0.01	P<0.01
Gender	0.03	0.00	0.76	0.95
Feedback and gender interaction	0.51	0.29	0.47	0.82

[a]SICR: Supine isometric chest raise; [b]SDSLR: Supine double straight-leg raise

Table 3: The comparison between the effects of four test conditions with each other on the endurance time of SICR test.

Test condition	Test condition to be compared	SEM[c]	P value
No feedback	VF[a]	2.14	P<0.01*
	VE[b]	3.87	P<0.01*
	VF[a]+VE[b]	5.00	P<0.01*
VF[a]	No feedback	2.14	P<0.01*
	VE[b]	3.83	0.84
	VF[a]+VE[b]	4.54	0.01*
VE[b]	No feedback	3.87	P<0.01*
	VF[a]	3.83	0.84
	VF[a]+VE[b]	4.21	P<0.01*
VF[a]+VE[b]	No feedback	5.00	P<0.01*
	VF[a]	4.54	0.01*
	VE[b]	4.21	0.01*

*Statistically significant: (P value<0.05). [a]VF: Visual feedback; [b]VE: Verbal encuragement; [c]SEM: Standard error of measurement

Table 4: The comparison between the effects of four test conditions with each other on the endurance time of SDSLR test.

Test condition	Test condition to be compared	SEM[c]	P value
No feedback	VF[a]	1.56	P<0.01*
	VE[b]	1.57	P<0.01*
	VF[a]+VE[b]	2.59	P<0.01*
VF[a]	No feedback	1.56	P<0.01*
	VE[b]	1.21	0.26
	VF[a]+VE[b]	1.82	0.03*
VE[b]	No feedback	1.57	P<0.01*
	VF[a]	1.21	0.26
	VF[a]+VE[b]	1.47	0.02*
VF[a]+VE[b]	No feedback	2.59	P<0.01*
	VF[a]	1.82	0.03*
	VE[b]	1.47	0.02*

*Statistically significant: (P value<0.05). [a]VF: Visual feedback; [b]VE: Verbal encuragement; [c]SEM: Standard error of measurement

that the participants could maintain testing positions for longer periodsof time. This event may be as a result of the subject's motivation.

Lactic acid is a normal by-product of muscle metabolism, and it is formed and accumulated in the muscle under conditions of high energy demand. However, lactic acid can irritate muscles and cause discomfort, pain, and soreness. It has been shown that visual feedback can modulate pain sensations [40], and can enable participants overcome their pain and increase the time of muscle contraction. Many studies have suggested that factors such as neural and morphological characteristics [23, 41], motivation [42, 43], competition, feedback, and verbal encouragement [44, 45] can alter motor neurons recruitments during voluntary muscle contraction.

Some studies have indicated that verbal encouragement improves muscle performance. [23, 46, 47]. Furthermore, Andreacci et al. demonstrated that oxygen consumption is strongly affected by verbal encouragement during maximal exercise testing [47]. Improvement in $VO2_{max}$ during an endurance task with verbal encouragement increased respiratory exchange ratio, maximum heart rate, and blood lactate concentration. The efficacy of task performance could also be strengthened by verbal encouragement. All these explanations could be the reason for increasing endurance tests time in asympomatic participants duringthis investigation.

Previousstudies have evaluated the effects of combined visual feedback and verbal encouragement on muscles' maximum strength and peak torque [21, 48]. The results of this study are in agreement with previous studies that revealed that combined visual feedback and verbal encouragement have superior effects compared to visual feedback or verbal encouragement alone [21, 48]. As expected and has been stated in the hypothesis, asymptomatic participants tended to maintain the testing positions for a longer period of time in each of the 3 feedback conditions. Although there have been no study to determine the effect of feedback on muscle endurance, our preliminary results showed that the visual/verbal feedback may be analternative way to enhance deep local muscle endurance in asymptomatic participants. Further studies need to investigate the effects of verbal/ visual feedback on muscle endurance in patients with muscloskeletal disorders such as low back pain. It seems that applying both visual and verbal feedback could be helpful in the rehabilitation of abdominal muscles endurance in patients with low back pain.

Finally, the limitation of the study is that the participants were asymptomatic with approximately normal body mass index (BMI). Therefore, the generalization of these findings is limited and the data obtained from asymptomatic participants is not representative of the population with low back pain. Further research is thus required to evaluate the effects of feedback on abdominal muscles endurance tests in symptomatic participants.

Conclusion

In conclusion, we state that there was a significant increase in the holding time of SICR and SDSLR tests when visualfeedback, verbal encouragement, or a combination was used. However, providing both feedbacks simultaneously seem to be more efficient compared to visual feedback or verbal encouragement separately.

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