University of Applied Science

English Stream Physiotherapy

"The Effect of Sitting Postures on the Motor Performance of the Trunk"

''Is the muscle activity of the lower back muscles changed after short term slump sitting?''

Bachelor Thesis

Version 1.0.

31/ 5 /2013

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Preface

Many people have heard someone tell them to “sit up straight”. I heard that command countless times in my teenage years and remember the rebellious wish to prove that there is nothing wrong about sitting slumped. A couple of years later I nearly completed my studies to become a physiotherapist and find myself telling others to “sit up straight” during my internships. The wish to find out if slumped sitting truly has negative effects on the body remained.

I got the chance to work on that question in my graduation project as part of the English stream physiotherapy course at Fontys University of Applied Science in Eindhoven, the Netherlands.

The title “the effect of sitting postures on the motor performance of the trunk'' was chosen in accordance with my co- worker in this project. We examined different aspects of motor performance whereby I focused on back muscle activity and she investigated postural sway.

I wish to thank Jaap Jansen for his support and guidance and the time he invested, even on his weekends! Many thanks to Tim Gerbrands for his help and patience in stressful moments in the gait laboratory. Thanks to Chris Burtin and Paul de Meurichy for taking care of the organization of the project.

I am very grateful for my wonderful classmates and the team- spirit that could be felt during the work on our thesis. Special thanks to Verena Mitterer, Sara Miribung and Julia Baumgart for peer reviewing. Thanks to Cliff Mathisen for helping me with language issues. I am also thankful for our models that kindly allowed us to take pictures and use them in the report. And last but not least, thanks to Leonie von Hagen, my encouraging and helpful co- researcher and friend: working on this project was more fun with you!

Theresa Ebert

Eindhoven, 31.05.2013

Abstract

Background information: Slumped sitting is associated with decreased back muscle activity and proprioception disturbances. An active posture is advocated to prevent those effects. Altered muscle activation patterns, disturbed proprioception and multifidus atrophy are commonly seen in people with low back pain. Slump sitting is a suspected risk factor for the development of low back pain.

Research question: „Is there a change in the back muscle activity after 20 minutes of slump sitting compared to 20 minutes of active sitting in young, healthy subjects?"

Study design: randomized controlled crossover study

Method: 19 healthy, young subjects were randomly assigned to start sitting actively on a gymball or slumped on a backless chair for 20 minutes. Before each sitting period they walked for 20 minutes. The activity of the lumbar multifidus and iliocostalis was measured at baseline and after both sitting conditions with superficial electromyography in seated balance and normal sitting for 60 seconds each.

Results: No significant difference was found when measuring on the balance board. On the normal surface, the activity of the iliocostalis and multifidus after both sitting positions was higher than the baseline. When comparing the activity of the multifidus with the illiocostalis, no significant difference could be found.

Conclusion: The differences after sitting and walking stresses the importance of active breaks during prolonged sitting to prevent low back pain. Stability and coordination training can be recommended to prevent altered muscle activation patterns that are related with low back pain.

Keywords: low back pain, slump sitting, multifidus, proprioception, stability, seated balance

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Introduction

Sitting accounts for a substantial amount of the day in Western society. According to a Dutch survey, people sit on average 7 hours per day (Jans et al., 2007). Employees in office occupation spend 82 % of their working time seated (Moerl et al., 2013). Prolonged sitting is suspected to be a risk factor for the development of low back pain (LBP) (O'Sullivan et al., 2002). LBP is a common problem: up to 84% of the population will experience LBP at least once in their life (Walker, 2000).

Sitting positions can be classified as active and passive. Slump sitting is defined as a passive sitting posture with a relaxed thoraco– lumbar spine and a posterior tilt of the pelvis (Caneiro et al., 2010). It is suspected that passive sitting postures are related to LBP (O'Sullivan et al., 2002).There are a number of negative factors associated with slump sitting. The passive lumbopelvic structures can get strained as they need to stabilize the spine in a slumped sitting posture (O'Sullivan et al., 2002; Hoops et al, 2007). The structures in the back are elongated and creep is occurring which affects their proprioceptive capability. The tissue recovery after 10 – 60 minutes of slump sitting takes more than 2 hours (Solomonow, 2009). It is suspected that the proprioception of the spinal stabilizers is affected by slump sitting. Already five minutes of slumping disturbs the lumbar reposition sense in healthy subjects (Dolan, 2006). The stretch of the back muscles impairs the correct afferent sensory information which might influence the motor performance (Georgy, 2011). The muscle activity of the following muscles is significantly lower in slump sitting compared to active sitting: the superficial lumbar multifidus (SM), iliocostalis lumborum pars thoracalis (ICO) and transverse fibres of the internal oblique abdominals (Dankaerts et al, 2006). A deactivation of those muscles was found during 40% of the working time in office employees (Moerl et al., 2013). To reduce the mentioned negative effects of slump sitting, an active posture is advocated. A gymball can be used to stimulate an active way of sitting as the amount of movement increases when sitting on a ball compared to a chair (Kingma et al., 2009).

The SM and ICO are both extensors of the lumbar spine but with differentiated tasks. The SM is a muscle rich in proprioceptors and is regarded as one of the most important local stabilizing muscles of the back. The ICO is a torque producing muscle and responsible for general trunk stabilization (Daneels, 2001; Luomajoki, 2010). A decreased activity of the SM in relation to the ICO can be seen in functional movements in LBP patients compared to healthy controls. The lumbopelvic muscle activation pattern is often impaired in LBP patients. This is suspected to be in relation with postural control disturbances (O'Sullivan et al., 2002; Dankaerts et al., 2006). For optimal postural control, the inputs from the visual, vestibular and proprioceptive systems are weighed by the central nervous system (CNS) and the most reliable source is identified and focused upon. Healthy subjects can adapt to changed conditions by switching between a rigid and a multi- segmental postural control strategy (Cleays et al., 2011). LBP patients present more often with a rigid postural control than healthy controls (Brugmagne et al., 2008). People with LBP tend to activate big back muscles to stiffen the spine in order to prevent pain (van Dieen et al., 2003; Watson et al., 1997). Unreliable lumbar proprioception is thought to be a cause for the rigid postural control (Brugmagne et al., 2008; Greorgy, 2011). Multifidus atrophy is common in LBP patients (Mazis et al, 2009). It could be suspected that the decreased SM activity that is related to the rigid postural control leads to SM atrophy which is commonly in LBP patients. A relation between multifidus atrophy, LBP and a lack of lumbar stability can be seen (Ekstrom 2008). As slump sitting also affects the lumbar stability and decreases the multifidus activity, it could be speculated that slump sitting possibly leads to multifidus atrophy and LBP.

Several studies have investigated the effect of slump sitting on the trunk muscle activity while the subject is sitting. However, these researches did not look at the effects that occur after the period of sitting. It is of interest if the disturbed proprioception and decreased muscle activity caused by slump sitting remain after a period of slumping. If the effects persist, it could be an indication that slump sitting is a risk factor for the development of LBP since LBP is also associated with disturbed proprioception and decreased muscle activity (Dolan et al., 2006; Solomonow, 2009; Dankaerts et al., 2006). Therefore, this study aims to find out if a difference in back muscle activity after slump sitting compared to active sitting can be seen when lumbar proprioception is challenged in a seated balance task.

As the muscle activity pattern of the SM and ICO is altered in LBP patients, it is of interest if slump sitting causes a changed muscle activity pattern in healthy subjects as well (Dieen et al.,2003; Watson, 1997). If changes in the activity patter of the SM and ICO can be found in healthy subjects after slump sitting, this would be a supporting argument that slump sitting is a risk factor for the development of LBP. Therefore, this study aims to compare the activity ratio of the SM and ICO after active and slump sitting.

The knowledge about the effect of slump sitting on muscle activity can enable physiotherapists to prevent back complaints related to sitting. They can gain insight in the effects of active and slumped sitting and can give patient education about sitting postures on basis of that knowledge. The results of this study may also give other suggestion to develop interventions and training methods for the prevention of LBP.

This leads to the research question „Is there a change in the back muscle activity after 20 minutes of slump sitting compared to 20 minutes of active sitting in young, healthy subjects?"

It is hypothesised that a difference in back muscle activity can be seen after active and slump sitting. It is also expected that the activity of the multifidus in relation to the iliocostalis will be lower after slump sitting.

Method

Study design

This randomized controlled crossover study was conducted at the Physiotherapy department of Fontys University of Applied Sciences in Eindhoven.

Subjects

19 students (9 male, 10 female) from the Fontys University of Applied Science in Eindhoven were recruited via email. The subjects were healthy students, aged 18 – 35, who were able to speak and understand English. Subjects with current back problems or back injuries treated by a physiotherapist within the last 2 years were excluded. Other exclusion criteria were vestibular disorders and any injuries or problems that impaired their ability to walk and sit normally for a period of 40 minutes. People having allergy against glue or tape were excluded, since surface EMGs had to be attached on the subjects lower back. The criteria were controlled by means of a questionnaire.

Ethical aspects

The study design involved no risks for the participants. The study was approved by the ethics committee of the Maxima Medisch Centrum, Eindhoven. Further approval was gained by the acceptance of the project plan (Appendix I). The subjects were informed beforehand about testing procedure and the handling of the personal data via an information letter (Appendix II) and verbal instructions. All subjects decided to participate voluntarily in this study. The data was handled anonymously. All subjects signed an informed consent form (Appendix III) before the start of the experiment. The involved data and the intellectual property rights and claims were handed over to Fontys University of Applied Sciences (Appendix IV), who committed itself to a confidentiality statement (Appendix V).

Research procedures

The research procedure is presented in the flowchart (Figure 1).

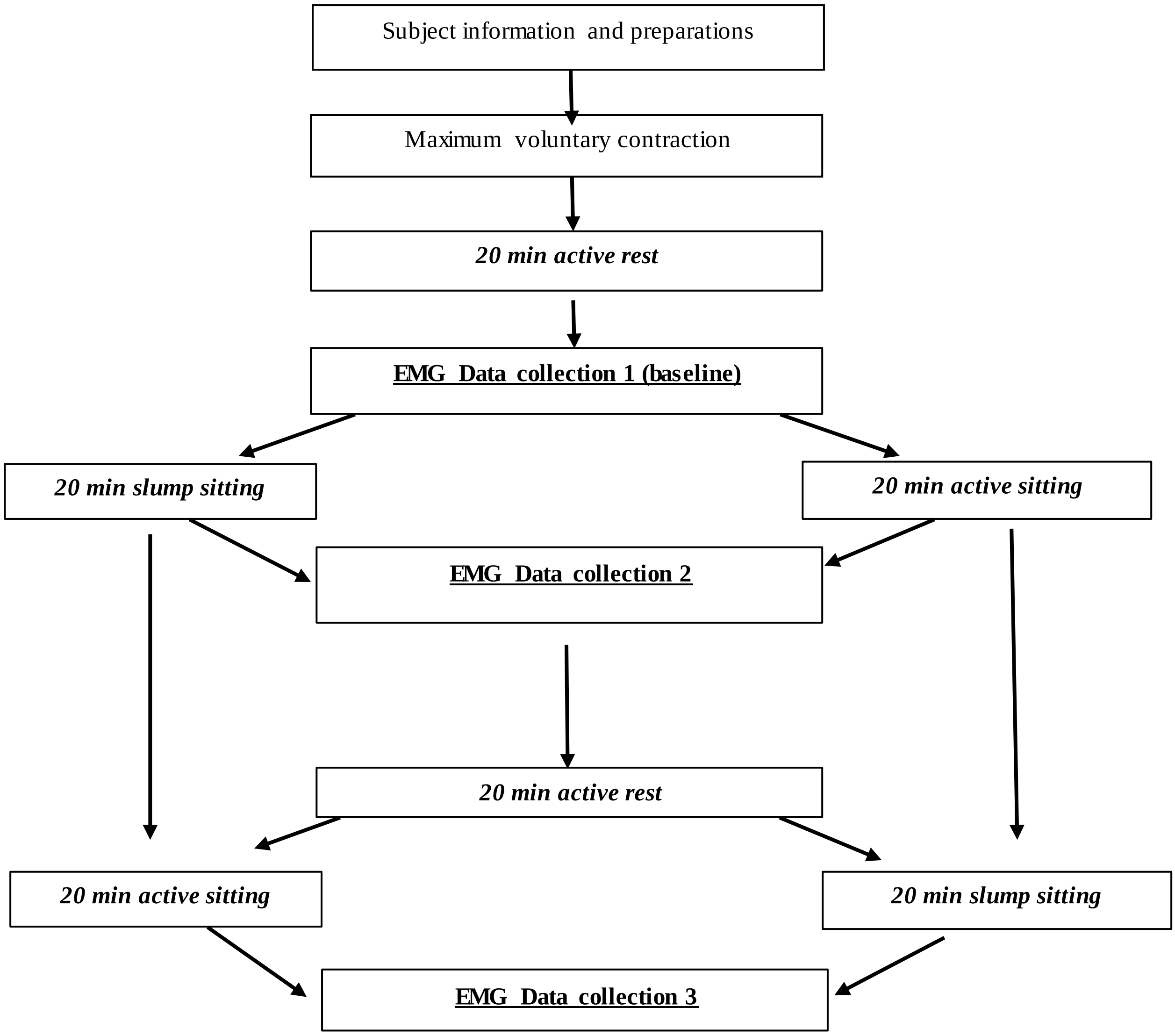

Figure 1: flowchart

The sitting duration was chosen to be 20 minutes as already 5 minutes slump sitting have shown significant proprioception disturbances (Dolan, 2006). 20 minutes more closely resemble a real life situation such sitting in a lecture or a meeting better than 5 minutes.

Subjects were seated for 20 minutes on a gymball for active sitting and on a backless, adjustable chair for slump sitting. For active sitting (Figure 2), subjects were instructed to keep their back upright and straight. They were allowed to move trunk and pelvis but were not allowed to support themselves with the hands on the legs or other objects. For slumped sitting (Figure 3), subjects were instructed to keep sitting with the lower spine flexed and relaxed without supporting themselves with the hands on the legs or other objects. The feet had to stay flat on the floor in both sitting conditions. If necessary, boards were placed under the feet to achieve an 90 degrees knee and hip angle. All verbal instructions were read from a standardized document at fixed times.

Figure 2: Active sitting

Subject is sitting w ith a straight back, hip and knee joints are in approx. 90° flexion, feet are flat on the floor

Figure 3: Slump sitting

Subject is sitting w ith a fully flexed and relaxed low er back, hip and knees are in 90° flexion, the head points straight forward. Feet are flat on the ground.

The subject were seated at a table and watched a movie on a laptop screen in one meter distance. This simulates looking at a screen during office work and ensured a similar state of activity from all the test subjects. Subjects were instructed to focus only on the movie and not engage in other activities. If subjects changed their sitting position drastically (i.e. slumped while in active sitting position, trunk rotation, crossed legs), they were reminded to adjust their posture accordingly.

Solomonow (2009) concluded that the spinal stabilizers need a 1:1 work recovery ratio to completely eliminate the effects of creep when working less than 60 min under static conditions. Therefore, the subjects had a period of active rest for 20 minutes in 1:1 ration with the duration of sitting. A study by Hoops et al (2007) found that when comparing a group with 5, 10 and 20min rest, only the 20 minutes rest group had a slow, uneventful recovery which was free of delayed hyperexcitability. Walking was chosen as an active rest period as it is a functional task in which the muscles need to work dynamically in contrast to the static work while being seated. Subjects could choose their own comfortable walking speed on the treadmill.

To test the muscle activity when stabilizing the spine, subjects were seated on a balance board (on a mobile force plate used by the co- researcher) which was placed at the edge of a table (Figure 4).The radius of the sitting surface was 26 cm and the balance cone had a radius of 11,8 cm with a height of 6 cm. The subjects could support themselves with the foot of their choice on an adjustable chair to avoid stabilizing attempts via body parts other than the lumbar spine and the stabilizing foot. For the second testing condition, subjects were seated directly on the mobile force plate to simulate a normal sitting surface (Figure 5). The subjects were asked to cross the arms in front of their body to ensure that the subject did not lean on the arms and all subject assumed the same arm position. Subjects were also asked to close their eyes as excluding visual input causes the subject to rely more on the somato sensory input (Claeys et al., 2011).

Figure 4: Seated balance

Subject sits on balance board, preferred foot stabilizes on the stool, eyes are closed, knees and hips are in approx 90°. Hands rest on opposite shoulders

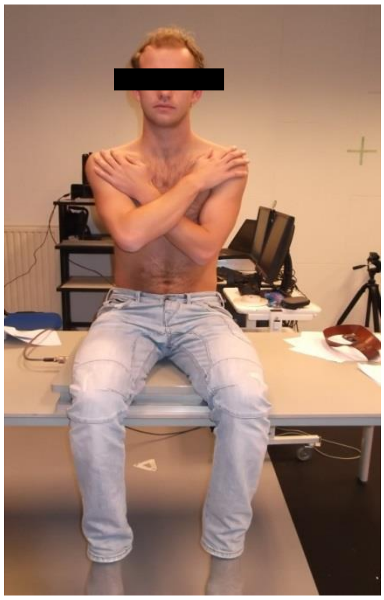

Figure 5: normal sitting

Subject sits on the mobile forece plate, feet hang freely, eyes are closed and the hands rest on opposite shoulders.

Subject preparation

Subjects were able to try out the balance testing position maximally 1-2 minutes and chose a foot on which he/she could stabilize better.

The subjects' skin was cleaned with alcohol and in case of body hair it was shaved. The wireless superficial EMG (sEMG) sensors were attached with self-adhesive tape in pairs and parallel to the muscle fibers. The location was established according to the method of O'Sullivan (2012) on the superficial lumbar multifidus (at L5 level, parallel to a line connecting the posterior superior iliac spine and L1–L2 interspinous space) and illiocostalis lumborum pars thoracalis (on the level of L1 spinous process, midway between the midline and lateral aspect of the subjects's body). As a maximum voluntary contraction (MVC) test, a prone back extension against gravity with the legs manually fixed on a treatment bench was performed. The test was repeated 3 times with an isometric contraction of 5 seconds. The EMG signal amplitude was recorded and proper electrode placement was confirmed by observing the EMG amplitudes during the test.

To randomize the order in which the sitting positions were taken, subjects drew an envelope from a basket.

Data collection

The data was collected after 20 minutes of walking (baseline measurement), after 20 minutes of slump sitting and after 20 minutes of active sitting (see flowchart 1). The data was collected during 60 seconds on the balance board and 60 seconds on a normal surface each time. In this study a surface EMG type Trigno Wireless, named Delsys EMG, produced by Delsys Incorporated was used.

Data analysis

The data were stored on a Hp Probook 656ob PC and the Delsys EMG works Analysis 4.0. Software was used for data processing and analysis. EMG signals were band-pass filtered from 20 to 400 Hz using a second-order band pass Butterworth filter. The raw EMG data were full-wave rectified and normalized against the MVC measurement. The maximum EMG signal amplitude during the MVC of each muscle represented 100% muscle activity.

Several sharp peaks of up to 400% of MVC were found in the graphs (Appendix VI). The normal muscle contraction velocity should be between 10 – 100 ms and the relaxation period that follows is usually longer than the contraction period. This can be seen on a myogram by a steep rise in muscle activity followed by a more gradual decline (Marieb, 2013). An unbiased person, blinded for the condition, was asked to visually inspect the data and choose a part of the graph which was representative for the graph but did not include peaks higher than 100% of MVC on the y- axis or peaks that were smaller than 20 ms on the x- axis. Since it is unphysiological that peaks are shorter than 20 ms and higher as during MVC, they were concluded to be technical measurement faults.

To exclude outliers the data was processed according to the Chaudmans criterion: Every measurement that was higher/lower than two standard deviations from the mean was excluded. That caused the exclusion of 14 out of 224 measurements. The remaining 210 measurements were processed via the computer program Statistical Package for the Social Sciences (SPSS) version 18. The data in this experiment was ratio data measured in the percentage of the MVC. The independent variable was the sitting position before the measurements took place, the dependent variables were the muscle activity of the tested muscles while seated on the balancing tool and the normal sitting surface.

The data was shown in a histogram per group and per variable/muscle. Through visual inspection it was concluded that the data was non- normally distributed for all variables. The median and interquartile range were optained. As a non- parametric test for related samples the Wilcoxon test was chosen. The muscle activity after the period of active sitting was compared with the activity after slump siting and the baseline measurement after walking. The activity between the SM and ICO within the same testing condition were compared and the ratio of the SM: ICO was compared in different testing conditions.

The p-value for the outcome measurements was α= 0,05. Should p be higher than 5%, the results of this experiment were considered coincidental.

Results

Subject Characteristics

16 subjects (7 male, 9 female) with a mean age of 23,5 (SD 2,28) years, mean height of 174 (SD 0,09) cm and mean weight of 68,63 (SD 10.5) kg were analysed.

Comparison of the muscle activity in different testing condition

The muscle activity of the ICO and the SM in % of MVC does not show significant differences (all p-values > 0,12) and are inconsistent when measured on the balance board and compared after the different testing positions (table 1, figure 1).

During sitting on the normal surface, the activity of the ICO after active sitting and after slump sitting are significantly higher as ICO baseline. The activity of the SM after active sitting is significantly higher than the SM baseline (p < 0,05). The SM after slump sitting showed a trend to be higher than the baseline (p = 0,084). There was no significant difference between active and slump sitting (p > 0,68); (table2, figure 1).

Comparison of the activity of the SM with the ICO

When comparing the muscle activity of the ICO with the SM (in % MVC) in the same testing condition, there is a tendency for the SM balance baseline to be higher than the ICO balance baseline (p= 0,078). For the other testing positions, no significance can be found (all p- values > 0,57); (table 3, diagram 1).

The activity ratio SM:ICO compared in different testing positions does not show any significance (all p-values > 0,27); (table 4).

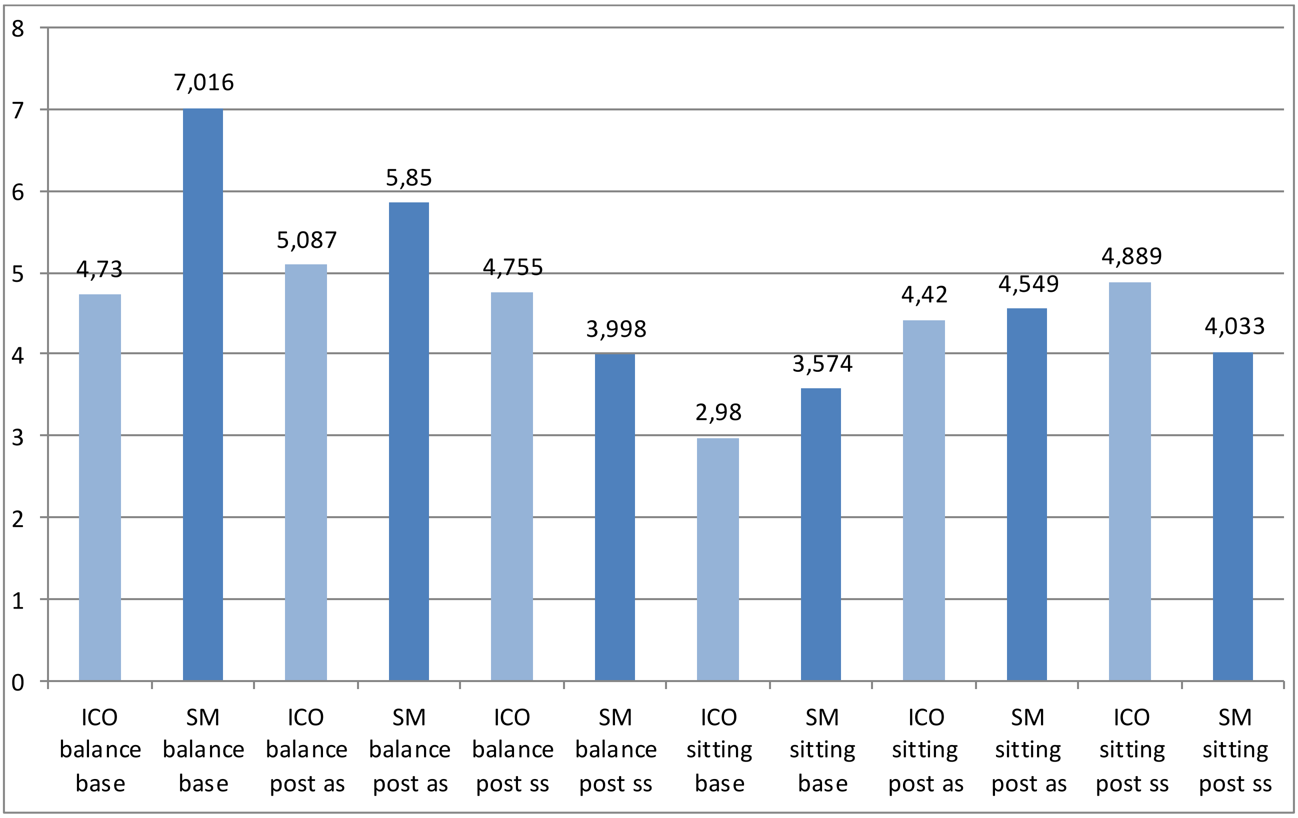

Figure 1: Muscle activity in % of maximum voluntary contraction.

ICO = illiocostalis lumborum pars thoracalis; SM .= superficial lumbar multifidus

base = baseline condition; post as = after active sitting; post ss = after slump sitting; balance = tested on the balance board; sitting = tested in normal sitting

Table 1: Comparison of the muscle activity on the balance board.

Testing condition	Median	IQR 25 %	IQR 75%	P – value*
ICO base	4,73	3,26	5,647	0,12*
ICO post ss	4,755	2,691	9,402	0,28^
ICO post as	5,087	2,323	7,457	0,69#
SM base	7,016	3,160	10,530	0,51*
SM post ss	3,998	1,914	9,596	0,36^
SM post as	5,85	3,021	9,603	0,78#

ICO = illiocostalis lumborum pars thoracalis, SM= superficial lumbar multifidus,
as= active sitting, ss= slump sitting, base= baseline measurement
* Differences between baseline and post as
# Differences between baseline and post ss
^Differences between post as and post ss

Table 2: Comparison of the muscle activity in normal sitting

Testing condition	Median	IQR 25 %	IQR 75%	P – value*
ICO base	2,980	2,283	4,924	0,022*
ICO post ss	4,889	2,158	11,023	0,027#
ICO post as	4,420	2,499	6,625	0,69^
SM base	3,574	1,460	4,913	0,035*
SM post ss	4,033	2,586	7,597	0,084#
SM post as	4,549	2,194	7,520	0,68^

ICO = illiocostalis lumborum pars thoracalis, SM= superficial lumbar multifidus,
as= active sitting, ss= slump sitting, base= baseline measurement
* Differences between baseline and post as
# Differences between baseline and post ss
^Differences between post as and post ss

Table 3: Comparison of the muscle activity of the SM and ICO in the same testing condition

Testing condition	Median	IQR 25 %	IQR 75 %	P - value
ICO base balance	4,727	3,257	5,647	0,078
SM base balance	7,016	3,160	10,530	
ICO post as balance	5,087	2,323	7,457	0,87
SM post as balance	5,847	3,021	9,603	
ICO post ss balance	4,755	2,691	9,402	0,826
SM post ss balance	3,998	1,914	9,596	
ICO base sitting	2,980	2,283	4,924	0,778
SM base sitting	3,574	1,460	4,913	
ICO post as sitting	4,420	2,499	6,625	0,570
SM post as sitting	4,549	2,194	7,520	
ICO post ss sitting	4,889	2,158	11,023	0,910
SM post ss sitting	4,033	2,586	7,597	

ICO = illiocostalis lumborum pars thoracalis, SM= superficial lumbar multifidus,
as= active sitting, ss= slump sitting, base= baseline measurement

Table 4: Comparison of the activity ration SM : ICO in the same testing condition

Ratio SM : ICO	Median	IQR 25 %	IQR 75%	P – value
Baseline balance	1,275	0,680	2,367	0,594*
Post ss balance	0,890	0,390	1,680	0,56^
Post as balance	0,705	0,260	1,860	0,510#
Base sitting	0,690	0,220	1,692	0,918*
Post ss sitting	1,130	0,560	1,940	0,26^
Post as sitting	0,790	0,400	2,15	0,71#

ICO = illiocostalis lumborum pars thoracalis, SM= superficial lumbar multifidus,
as= active sitting, ss= slump sitting, base= baseline measurement
* Differences between baseline and post as
# Differences between baseline and post ss
^Differences between post as and post ss

Discussion

This aim of this study was to find out if differences in the back muscle activity can be seen after a period of slumped and active sitting. It also aimed at showing possible differences in the activity of the SM and ICO after slumped and active sitting.

The effect of slump sitting on the muscle activity of the back muscles

It was hypothesised that a difference can be seen in the back muscle activity in a seated balance task after slump sitting compared to after active sitting. Already 5 minutes of slump sitting shows significant disturbances in lumbar proprioception (Dolan et al., 2006). When the proprioceptive information is unreliable, bigger muscle groups increase in activity to stiffen the spine (Brugmagne et al., 2008). Contrary to what was expected, no difference in muscle activity during the seated balance task could be found. This could lead to the assumption that a seated balance task after slump sitting does not lead to a change in the postural control strategy (Claeys et al., 2011). An explanation could be that a balancing task does not increase the demand for local proprioception. Kiers et el. (2012) found that standing on an unstable surface does not demand a higher ankle proprioception than standing on a stable surface. The CNS is able to shift the demand for proprioceptive signals to other body parts (Kiers et al., 2012). This shift can also be seen when a certain body part is malfunctioning. LBP patients tend to use other body parts instead of the trunk for proprioceptive information in balancing tasks (Brugmagne et al., 2004). Changed trunk kinematics are another reaction to a balancing task that can be seen in people with LBP (Willigenberg et al., 2013). The studies of Willigenberg and Kiers on LBP patients cannot be directly compared to this study on healthy subjects. But the mentioned studies clarify that the body is able to compensate by using proprioceptive information from other body parts or changing kinematics. The possibility needs to be considered that the subjects in this study could mainly have used the proprioceptive information gained through the foot support. A disturbed sensory input would cause a disturbed motor output which was not the case in this study (Georgy, 2011). Therefore, the theory that the body can compensate for the disturbances in sensory input caused by slump sitting could be an explanation for the results.

That line of reasoning is also supported by the fact that there were significant results found when measurements were taken on a normal surface. The muscle activity after a period of active sitting and slump sitting was higher than at baseline after 20 minutes active rest (walking). But there was no significant difference when comparing the muscle activity after slump sitting and active sitting. As the muscle activity after both sitting positions was significantly higher than at baseline it can be assumed that the type of sitting condition and posture does not have an influence on muscle activity. The difference in muscle activity between walking and sitting appears big enough to show significant changes after a period of 20 minutes. During walking the activity of the SM and ICO is twice as much as during normal sitting (Mork et al., 2009). That leads to the question if the muscle activity during slump sitting and active sitting are different enough to show differences afterwards. No differences in back muscle activity could be found in studies that examined sitting for 5, 30 or 60 minutes on an unstable surface compared with a stable surface (Mc Gill et al., 2006; Gregory et al., 2006; O'Sullivan et al., 2006). In contrast, Kingma et al (2009) found a significant increase in muscle activity of the lower back muscles during an one hour typing task while sitting on a ball when compared to sitting on a chair. The method of the above mentioned studies are comparable with each other and this study. All studies tested the muscle activity with sEMG on the lower thoracic and lumbar area on healthy subjects. An inflatable ball or cushion was used for the unstable sitting condition. The effects of the stable and unstable sitting condition were compared within the same subject. Besides the sitting surface no changes were made in the environment, task or posture of the subjects between the two conditions. It needs to be mentioned that those studies focused on the sitting conditions but not the sitting posture. Subjects in the above mentioned studies did not receive different instructions concerning the sitting posture when sitting on the ball and on the chair. In this study, the instructions for the period of slump sitting were very strict and did not allow any movement. On the gymball, subjects were supposed to sit upright and were allowed, but not instructed, to move their pelvis and trunk but most subjects remained motionless. As they did not move it could be assumed that subjects adopted a rigid, upright posture which requires an increased muscle activity. This may affect postural control (Reeves et al., 2006). O´Sullivan et al (2012) showed that sitting on a ball can result in muscle fatigue and perceived discomfort. It can be concluded that it is likely that the both sitting postures have an effect on muscle activity and postural control. The sitting posture and conditions do not appear different enough to display differences in muscle activity after 20 minutes of sitting.

The fact that only Kingma et al (2009) found an increase in muscle activity could be caused by the tasks that were performed by the subjects while sitting: the back muscle activity was significantly higher when performing a typing task compared with reading a text on the screen (Gregory, 2006). In this study, all subjects watched a movie on a laptop which is comparable with reading a text on a screen. There was no task given that required movement and subjects were asked not to engage in conversations or to turn around. By doing that, external influences and differences caused by activities could be excluded and subjects could be compared better with each other. It could be speculated that a difference in back muscle activity could have been found if a secondary task such as typing was performed.

<u>The effect of slump sitting on the activity ratio of the SM : ICO</u>

When seated on the balance board for the first time (baseline), the activity of the SM was higher than the ICO (p= 0,078). Kingma et al (2009) also found an increase of muscle activity of the lumbar muscles (level L3) but not of the lower thoracic muscles (level Th10) in unstable sitting when compared to stable sitting. Therefore it can be assumed that it is normal muscle activation pattern that the SM activity is higher than the ICO in unstable sitting.

Dankaerts (2006) found that the activity of the multifidus is significantly lower during slump sitting than during active sitting. Those muscle activity patterns seem to persist after the sitting period as this study found a lower activity of the SM than the ICO after slump sitting and higher after active sitting. This was the case when measured in seated balance as well as normal sitting, but there was no significance. This outcome reflects the activity pattern of the SM and ICO that can also be seen in LBP patients. When performing functional tasks, they present with an increased activity of bigger muscles such as the ICO and a decreased activity of smaller, stabilizing muscles such as the SM. This is explained with the rigid postural control often seen in LBP patients and the theory that LBP patients stiffen up the spine by activating big muscle groups to prevent pain (Cleays et al., 2011; Dieen et al., 2003; Watson et al., 1997). When pain is induced in healthy subjects via a saline injection in the multifidus, the activity in standing weight shifting tasks decreases (Kiesel et al., 2012). The above mentioned studies all found a decrease in the activity of the SM in relation to the ICO in subjects with (induced) LBP. It could be suspected that prolonged slump sitting may be a riskfactor for the development of LBP as similar patterns were observed in this study and in studies on LBP patients.

To be able to stabilize the spine, an adequate activity level of the multifidus is needed. A decreased activity of the multifidus after slump sitting therefore indicates that the spinal stability might be affected. Cholewicki and McGill (1996) tested the multifidus activity in several postures and movements. They found that the multifidus activity was near zero (% MVC) in situations when subjects were unstable. The study found that a multifidus activity of 1-3% of the MVC is enough to provide sufficient spinal stability. In this study the MVC percentage of the SM was always bigger than 3,58% of MVC. According to the results of this study, short term slump sitting does not cause an insufficiency to stabilize the spine in young, healthy adults.

<u>Strengths and Limitations of the study</u>

According to the knowledge of the researcher this study is the first that tests the muscle activity in seated balance after a period of slump sitting compared to active sitting. The influence of a sitting position or condition on the muscle activity of the back muscles *while* being seated has been tested frequently. This research introduces a new field of study by observing the effects on muscle activity *after* a period of sitting. Most studies focus on the comparison between healthy and LBP subjects in relation with LBP rehabilitation. This study only used healthy subjects and is more relevant for the prevention of LBP. The results of this study can enable researchers and health care professionals to learn more about the effects of sitting postures on back muscle activity.

The comparison of the results with other studies was complicated by the differences in the testing set up. Cholewicki et al. (2000) performed a similar study which was also repeated by other researchers that examined seated balance such as Reeves (2006). Cholewicki also used a balance board which was placed directly on a force plate. Additionally, there was a safety railing and a foot support that was attached to the balance board which means the subject does not have an external base of support. In this study, subjects supported themselves with one foot on a rotating, adjustable chair and did not have a safety railing. In Cholewicki's study measurements were taken for 7 seconds after subjects have found a stable position on the balance board. In this study many subjects reported the testing condition as difficult and lost balance. When subjects lost balance the recording was not stopped, repeated or excluded. This had an influence on the data collection.

Because of measurement problems with the used EMG the data of only 16 subjects could be analysed. In the EMG graphs it can be seen that unphysiological peaks were mainly found in the seated balance condition and not when sitting on the normal surface. The peaks could be due to extreme movements in attempts to regain balance which might cause a loss of contact between the skin and the sensor or friction of clothing. When subjects lost balance and the balance board touched the table it caused an external, high intensity impuls that could have been registered by the EMGs. Due to those peaks, the data had to be filtered manually by an non biased person who chose a part of the graph without any unphysiological peaks. This made the use of the data possible but blurred the picture since the extreme values were taken out and the values of all conditions became more similar.

In some cases the EMGs were not attached properly to the skin and the tapes needed to be replaced. In two cases the batteries went empty and had to be recharged while the subjects were sitting. The position of the sensors was marked before removing them to be able to correctly replace them but an influence of that removal cannot be excluded.

Especially the multifidus which lies in close proximity to other muscles is prone to "crosstalk" which is the interference of signals from several muscles underlying the skin sensor (Stokes et al, 2003). The chance to collect potentials from only one muscle are lower when using sEMG than intra muscular EMG. The intramuscular electrodes collect data more accurately and the use is recommended especially for the multifidus (Stokes et al, 2003). However, the use of EMG that penetrate the skin was not applicable in this study for ethical reasons.

Implications

This study could not show differences in muscle activity between active and slumped sitting but it showed a significant difference after a period of either slump or active sitting compared with a period of active rest. This stresses the importance of having active breaks such as walking, especially when sitting for longer periods of times. As the active and slumped sitting posture seem to affect the lumbar muscle activity, it could be recommended to change sitting postures frequently.

This study found a higher activity of the SM in comparison with the ICO after active sitting and active rest but a slightly lower activity after slumped siting. As it is suspected that static sitting could cause LBP, the following studies are presented to answer the question if dynamic sitting can be an option to prevent and treat LBP. In an experiment by Bridger (2000) 54 office workers suffering from LBP, were advised about ergonomically improving their workspace and the intervention group additionally received either a gymball or a kneeling chair. The intervention group presented with very different individual results but a reduction in LBP, measured on the VAS scale, was seen. A systematic review by O'Sullivan et al (2012) who analysed 7 articles that compared the intensity of LBP in a dynamic and static sitting condition found inconsistent results with some articles that reported significant improvement in LBP when sitting dynamically. O' Sullivan concluded that a dynamic sitting condition can therefore be an option to prevent and treat backpain but cannot be regarded as a stand-alone approach. It is essential information for a physiotherapist that only focusing on the improvement of sitting postures and conditions cannot be successful.

Denkaerts et al (2006) and this study showed a relation between slump sitting and reduced multifidus activity. In LBP patients even multifidus atrophy can be found (Mazis et al, 2009). Therefore, it should be a concern of the physiotherapist to prevent or reverse multifidus atrophy by training. Studies show that multifidus atrophy can be prevented by doing stability exercises (Ekstrom et al., 2008). A stability training program with a gym ball according to Carter et al (2006) shows significant improvement in spinal stability and could be recommended. In a study by Daneels et al (2002) it was found that the activity of the SM is significantly decreased in coordination exercises in LBP patients compared with a healthy control group. Daneels concludes that LBP patients might lose the ability to voluntarily recruit the SM which is essential to maintain the natural lordosis. Physiotherapists could therefore focus especially on lumbar stability and coordination training to prevent multifidus atrophy and by doing that decreasing the risk for LBP.

Recommendations

Further research is recommended with a bigger sample size. To give better insight in the effects of long term sitting, the periods of sitting should be extended to more than 20 minutes. A more complete picture could be obtained by measuring muscle activity during slumped and active sitting aswell. It could be helpful to repeat the research with the same testing set up as Cholewicki (2000) as that would make comparison with other studies easier. The instructions for the sitting positions should be more specific and should aim for bigger differences in muscle activity while sitting actively/ slumped. The type of EMG that will be used should be tested in a pilot study to ensure it collects data in different conditions correctly. To make the results of the EMG more reliable an intramuscular EMG should be considered.

Conclusion

When measured in seated balance, there was no significant difference in back muscle activity found when comparing baseline and after slump and active sitting. When measured in normal sitting, there are significant differences in muscle activity between the baseline measurement (after walking) and both sitting position. This is relevant information for physiotherapists to give patient education about active breaks and frequent changes in sitting postures during prolonged sitting to prevent LBP.

The activity of the SM is lower than the ICO after slump sitting and higher after active sitting, however no significance was found. This pattern is also seen in LBP patients. Physiotherapists can aim to prevent pathological muscle activity patterns with stability and coordination training.

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Appendices

Appendix 1: Project plan approval

B4 Assessment form project plan

Name: Therese Ebert Student no:

Date: 3-2-2013

Title:does slump sitting affect motor performance of the trunk?

General

- The project plan is according to format	yes
- Spelling and language are correct	yes

Problem description and problem definition (introduction)

- The problem description is sufficiently clearly formulated	yes
- The problem description reflects social and paramedical relevance	yes
- A concrete and relevant research question (or questions) can be formulated based on the problem definition, including possible sub questions	yes

Objective

The objective is:

- Sufficiently clearly and concretely formulated	yes
- Relevant for a selected target group within the (paramedical) professional practice	yes
- Practically feasible	yes
- Achievable within the set time	yes

Project product

The project product:

- Is in line with the problem definition, research question and objective	yes
- Is usable for the selected target group	yes
- Is in line with the client's wishes	NA
- The product requirements are accurately described	yes / no

Activities/method

Sufficient insight is given into the type of activities and types of sources for the performance of the research and the realization of the product	yes

Time schedule

- The time schedule gives a global phasing and time investment for the project as a whole and for the coming weeks an increasingly detailed schedule	yes
- Important moments are recorded in the table (typographically noticeable) (e.g. contact moments, handing-in moments)	yes
- The time schedule gives a global task division of the planned activities	yes

Estimated costs

Clear insight is given in:

- The costs to be expected concerning money and hours	yes
- The division of these costs (project leader, student, programme)	yes

Literature

- Used and planned literature is specific and mentioned to a sufficient extent	yes
- Relevant and recent literature is referred to	yes
- Literature references, in the text and in the literature list, are made according to the Writer's Guide (Wouters 2012)	yes

Comments: In general a good project plan. activities and methods need to be expanded a bit more in the final research report: see comments in you project plan.

All points under B3.1 up to and including B3.8 must be answered with a 'yes' in order to receive a GO for the project. The supervisor discusses with the student which points need adjustment.

GENERAL: **GO**

Name assessor ____________________ Date + Signature ____________________

Appendix II: Information letter

Graduation research project

Motor control of the trunk – Information letter

Dear student,

We (Leonie and Theresa, 4th year students English stream Physiotherapy). like to ask you kindly to participate in our study that investigates the motor control of the trunk.

In order for you to decide if you would like to participate we will give you some information about the study. Please read through it and contact us in case of any questions. Our contact information is given at the end of the information letter and we are happy to answer your questions and tell you more about the project.

What is the aim of the research?

The stability and control of the trunk is an important factor in daily life tasks such as sitting and changing positions. Longer times of sitting in a slumped position (flexed, relaxed lower back). may influence the ability to stabilize the back negatively and can lead to back pain. Research does not fully agree on it yet and this project aims to find out more about it.

How is the research conducted?

We would like to assess the effect of slumped sitting and active straight sitting on the trunk stability. We will ask participants to sit in an active and slumped position for 20 minutes each. Afterwards the ability to control and stabilize the trunk will be assessed on a seated balance tool. You can support yourself with one foot on th e floor and the researchers will be close to you in case you may lose balance. While being seated on the balance tool we will collect data from the force platform under the chair and through the electromyography sensors that are attached to your skin on the lower back. In between the sitting periods you will be walking on a treadmill at a comfortable, self-chosen walking speed for 20 minutes.

Who can participate?

Every young and healthy person can participate in the study. People with an allergy to tape or glue are excluded since the sensors will be stuck on the skin. So if you are between 18 -35 and didn't have any past or present back complaints for which you received physiotherapy and no lower limb injuries or complaints that impair your ability to sit and walk normally, you can do us a great favour by participating.

Are there risks?

There are no risks related to the research. There will always be the team of researchers and a supervising teacher in the gait lab in case of unforeseen events and to assist you. You can decide to stop the research at any point. Your participation is entirely voluntarily. Even after the research conduction you can step back from participation and we won't use your data in that case.

What are the advantages and disadvantages?

The only disadvantage will be that you need to invest about 2 hours of your time. The exact time will be chosen together with you so that it can fit your schedule. There are not costs for you involved and since the research is conducted in the gait lab of Fontys you don't need to travel to get there. It can be an advantage for your own health to find out if a slumped sitting position might influence your motor control negatively and thereby increase your risk for back pain. If you wish we can give you information about the data that we collected from your testing.It is also helpful to participate in a thesis study to get a first impression how a thesis is structured and conducted as a preparation for your own thesis at the end of your studies.

Are you insured when taking part in this research?

Since the research is conducted on healthy adults and involves minimal risks the medical ethical test committee of maxima medisch centrum has approved the research and has confirmed the research as non WMO – obliged. In case of unforeseen events you will be insured via Fontys University of Applied Science.

What happens with the data?

The data will be anonymous and can't be related to your person. The data will be analysed and used for our thesis project. It will be stored for 5 years and other researchers might get the possibility to access it. The data will be anonymous and coded, only the team of researchers have the key to uncode the collected data.

Would you like to know more?

You can always approach Leonie and Theresa as the team of researchers with any questions. In case you want to contact the supervisor of the research project and the testing sessions you are free to get in touch with Dr Jaap Jansen. For general questions, complaints or advice about participation you can approach Dr Chris Burtin who is organizing the thesis project.

We hope to hear back from you and welcome you in the research!

Leonie and Theresa

Contact information

Researching students:

Theresa Ebert, T.ebert@student.fontys.nl, 0643810312

Leonie von Hagen, l.vonhagen@student.fontys.nl 0681285366

Supervisor: Dr. Jaap Jansen, Jaap.jansen@fontys.nl , 088-50 89866

Organizer: Dr. Chris Burtin, c.burtin@fontys.nl088-50 889842

Appendix III: Informed consent

Agreement about participation in the research about motor control of the trunk

I have read the information letter about the research project and was able to ask any possible questions that were sufficiently answered.

I had enough time to decide about participation in the research project. I know that the participation is entirely voluntarily and I know that I can renounce my participation at any moment without a reason.

I know that the people mentioned in the information letter will have access to my data and I agree that my data will be stored anonymously for 5 years and might be used for other research projects. I give permission to use my data for the aims described in the information letter.

I agree to participate in the research.

Name test person::

Signature: Date : __ / __ / __

I state that I have informed the test person fully about the testing procedure.

If there is any information during the research that could change the agreement to participate of the test person I will inform him/ her in time.

Name researcher (representative).

Signature: Date: __ / __ / __

Additional information is give by (if applicable).

Name

Function:

Signature: Date: __ / __ / __

Appendix IV : Conveyance of rights

AGREEMENT

Pertaining to the conveyance of rights and the obligation to

convey/return data, software and other means

The undersigned:

1. Ms Theresa Ebert
   residing at 77704 Oberkirch, Germany
   at the Schauenburgstrasse 9
   hereinafter to be called "**Student**"

and

2. Fontys Institute trading under the name Fontys University of Applied Sciences, Rachelsmolen 1, 5612 MA Eindhoven, hereinafter to be called "**Fontys**"

CONSIDERATION

A. Student is studying at the Fontys Paramedic University of Applied Sciences in Eindhoven and is performing or will perform (various) activities as part of his/her studies, whether or not together with third parties and/or commissioned by third parties, as part of research supervised by the lectureship of Fontys Paramedic University of Applied Sciences. The aforesaid activities will hereinafter be called "**Lectureship Study Activities**". At the time of the signing of this Statement, the Lectureship of Fontys Paramedic University of Applied Sciences supervises in any case the studies listed in Appendix 1, but this list is not an exhaustive one and may change in the future.

B. It is of essential importance to Fontys Paramedic University of Applied Sciences that (the results of) the Lectureship Study Activities can be further developed and applied without any restriction by Fontys Paramedic University of Applied Sciences and/or used for the education of other students. Fontys wishes in any event – but not exclusively – (i) to be able to share with and/or convey to third parties (the results of) the Lectureship Study Activities, (ii) to publish these under its own name, where the Student may be named as co-author providing that this is reasonable under the circumstances, (iii) to be able to use these as a basis for new research projects.

C. In case intellectual ownership rights and/or related claims on the part of Student will be/are attached to (the results of) the Lectureship Study Activities, parties wish – taking into account that which was mentioned under (B) – Fontys Paramedic University of Applied Sciences to be the only claimant with regard to said rights and claims. The Student therefore wishes to convey all his/her current and future intellectual property rights as well as related claims concerning (results of) the Lectureship Study Activities to Fontys, subject to conditions to be specified hereafter;

D. Student furthermore wishes to enter into the obligation – again taking into account that which was mentioned under (B) – to convey all data collected by him/her as part of the (results of) the Lectureship Study Activities to Fontys and not to retain any copies thereof, and also to return all data, software and/or other means previously provided by Fontys as part of (the results of) the Lectureship Study Activities, such as measuring and testing equipment, to Fontys without retaining copies thereof, all the above being subject to conditions to be specified hereafter.

AGREE THE FOLLOWING

Conveyance of intellectual property rights

1.1 Student herewith conveys to the Fontys Paramedic University of Applied Sciences all his/her current and future intellectual property rights and related claims concerning (the results of) the Lectureship Study Activities, for the full term of these rights.

1.2 Intellectual property rights and/or related claims are understood to refer to, in any case – but not limited to – copyright, data bank law, patent law, trademark law, trade name law, designs and model rights, plant breeder's rights, the protection of know-how and protection against unfair competition.

1.3 The conveyance described under 1.1 shall be without restriction. As such, the aforesaid conveyance shall include all competences related to the conveyed rights and claims, and said conveyance shall apply to all countries worldwide.

1.4 Insofar as any national law requires any further cooperation on the part of Student for the conveyance mentioned under 1.1, Student will immediately and without reservation lend such cooperation at first request by Fontys Paramedic University of Applied Sciences

1.5 Fontys accepts the conveyance described under 1.1.

Waiver of personal rights

2.1 Insofar as permitted under article 25 'Copyright' and any other national laws that may apply, Student waives his/her personal rights, including – but not limited to – the right to mention Student's name and the right to oppose any changes to (the results of) the Lectureship Study Activities. If and insofar as Student can claim personality rights pursuant to any national laws notwithstanding the above, Student will not appeal to said personality rights on unreasonable grounds.

2.2 In deviation from that which was stipulated under 2.1, the Fontys Paramedic University of Applied Sciences may decide to mention the name of Student if this is reasonable in view of the extent of his/her contribution and activities.

Compensation

Student agrees that he/she will receive no compensation for the conveyance and waiver of rights as described in this Statement.

Guarantee concerning intellectual property rights

Student declares that he/she is entitled to the aforesaid conveyance and waiver, and declares that he/she has not granted or will grant in future, license(s) for the use of (the results of) the Lectureship Study Activities in any way to any third party/parties. Student indemnifies Fontys from any claims by third parties within this context.

Obligation to convey/return data, software and other means

5.1 At such a time as Student is no longer performing any Lectureship Study Activities and/or is no longer a student at Fontys, Student is obliged to convey to Fontys all data, in the widest sense of the word, collected by him/her as part of (results of) the Lectureship Study Activities, including – but not limited to – studies and research results, interim notes, documents, images, drawings, models, prototypes, specifications, production methods, process descriptions and technique descriptions.

5.2 Student guarantees not to have kept any copies in any way or form of the data meant under 5.1.

5.3 Student is obliged to return to Fontys all data, software and other means provided to him/her by Fontys as part of the Lectureship Study Activities, and guarantees not to have kept copies in any way or in any form, of the provided software and/or other means.

5.4 Student agrees that if he acts and/or proves to have acted contrary to the obligations mentioned under 5.1 up to and including 5.3, (a) he/she shall be liable for all and any damages incurred or to be incurred by Fontys, and (b) that this will qualify as fraud and that Fontys can apply the appropriate sanctions hereto. The sanctions to be applied by Fontys may consist of, among other things, the denying of study credits, the temporary exclusion of the Undersigned from participation in examinations, but also the definitive removal of the registration of the Undersigned as a student at Fontys.

Waiver

Student waives the right to terminate this Agreement.

Further stipulations

7.1 Insofar as this Agreement deviates from the Student Statute, this Agreement shall prevail.

7.2 This Agreement is subject to Dutch law. All disputes resulting from this statement will be brought before the competent judge in Amsterdam.

Student:

Fontys Institute

trading under the name Fontys Hogescholen

Supervisor:

Name: Theresa Ebert

Name: ___________________________

____

(signature)

Date:29/05/2013

Place: Eindhoven

____

(signature)

Date:__/__/_____

Place: __________________

I, Ms. M.H. de Waard, sworn translator for the English language registered at the Court in Groningen, the Netherlands, and registered in the Dutch Register of Sworn Translators and Interpreters (Rbtv) under nr. 2202, herewith certify the above to be a true and faithful translation of the attached Dutch document into the English language.

Groningen, 23 May 2012,

[M.H. de Waard]

Appendix V: Confidentiality statement

Name: Theresa Ebert Student No°: 2146381

Title: "The Effect of Sitting Postures on the Motor Performance of the Trunk''

____

Content (description):

Background Information: Slumped sitting is associated with decreased back muscle activity and proprioception disturbances. An active posture is advocated to prevent those effects. Altered muscle activation patterns, disturbed proprioception and multifidus atrophy are commonly seen in people with low back pain. Slump sitting is a suspected risk factor for the development of low back pain.

Research question: „Is there a change in the back muscle activity after 20 minutes of slump sitting compared to 20 minutes of active sitting in young, healthy subjects?"

Study Design: randomized controlled crossover study

Method: 19 healthy, young subjects were randomly assigned to start actively sitting on a gymball or slumped on a backless chair for 20 minutes. Before each sitting period they walked for 20 minutes. The activity of the lumbar multifidus and iliocostalis was measured at baseline and after both sitting conditions with superficial electromyography in seated balance and normal sitting for 60 seconds each.

Results: No significant difference was found when measuring on the balance board. On the normal surface, the activity of the iliocostalis and multifidus after both sitting positions was higher than the baseline. When comparing the activity of the multifidus with the illiocostalis, no significant difference could be found.

Conclusion: The differences after sitting and walking stresses the importance of active breaks during prolonged sitting to prevent low back pain. Stability and coordination training can be recommended to prevent altered muscle activation patterns that are related with low back pain.

1. By signing this Statement, the Fontys Paramedic University of Applied Sciences in Eindhoven commits itself to keep any information concerning provided data and results obtained on the basis of research of which is taken cognizance as part of the above practical research project and of which it is known or can be reasonably understood that said information is to be considered secret or confidential, in the strictest confidence.

2. This confidentiality requirement also applies to the employees of the Fontys Paramedic University of Applied Sciences, as well as to others who by virtue of their function have access to or have taken cognizance of the aforesaid information in any way.

3. The above notwithstanding, the student will be able to perform the practical research project in accordance with the statutory rules and regulations.

Student: **Supervisor:**

Name: Theresa Ebert______

____

(signature) Date:28 /05/2013

Name: ______________________________

____

(signature) Date:__/__/_____

Coordinator: for receipt

Name: ______________________________

____

(signature) Date:__/__/_____

Appendix VI: EMG outliers