

Fontys University of Applied Sciences

Physiotherapy English Stream

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

Does short term slump sitting affect the amount of postural sway in a young, active adult?

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Preface

This study was performed as a final part of the physiotherapy bachelor degree. The topic was deemed interesting since being a student has cost me many hours behind a desk in various sitting positions. During the last years of studying physiotherapy, I have learned that it is beneficial to try to prevent problems before they occur, instead of undergoing extensive treatment once a problem appears. Consequently, I wanted to find out if specific sitting positions affect spinal stability more than others. Therefore this article is mainly written for physiotherapists and people working in a preventive sector. The author hopes to have inspired readers to continue further research on this topic.

I would like to thank my supervisor Jaap Jansen for his continuous feedback, hours spent in discussing problems and keeping me on the right track. Further thanks go to the thesis coordinator Chris Burtin.

Special thanks go to my co-worker Theresa Ebert, for her help in setting up the experiment and keeping track of time management. Thanks for being so supportive and such a good friend. I am also thankful to Sara Miribung, Verena Mitterer and Julia Baumgart for their peer-reviewing and helpful comments and, of course, to the picture models for looking so nice. Further, I would like to thank Florian Exner for keeping my motivation and good spirits up and running and for enduring my mood swings.

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Abstract

Background Information: Slumped sitting has been associated with low back pain. Low back pain has shown to affect postural stability. In the lower back of a healthy person, little is known about the effects slump sitting has on motor control and sway.

Objective: To investigate if there are differences in the amount of sway and sway velocity after a period of slump sitting compared to a period of active sitting.

Research Question: Does short term slump sitting affect the amount of postural sway in a young, active adult?

Study Design: Randomized controlled crossover study.

Methods: 11 healthy, active subjects were asked to sit for 20 minutes in a slumped position on a backless chair and 20 minutes in an upright position on a gym ball. At the start and between the sitting positions, they were asked to walk for 20 minutes. Measurements were obtained via a force plate at baseline and after each sitting position. Subjects sat on a balance tool and directly on the force plate for 60 seconds each during data collection.

Results: No significant differences could be found. Small, though non-significant decreases of sway in medial-lateral direction, path travelled by the center of pressure and vector velocity were found on the balance board only between active sitting and baseline. On the mobile force plate, only slump sitting compared to baseline showed a non-significant decrease in sway in anterior-posterior direction.

Conclusion: The findings suggest a non-significant influence of both sitting postures on sway and sway velocity. This implies that physiotherapists should not teach one specific sitting position but rather frequent changing of posture.

Key Words: slump sitting, postural sway, proprioception, low back pain, stability, seated balance, motor control.

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Introduction

Sitting is a common daily activity. A study performed in 2003/04 in the United States found that depending on the age group, adults spend between 55 and 60% of their waking hours in a seated position (Matthews et al., 2008). Sitting is often named a factor which exacerbates low back pain (LBP) (Dankaerts et al., 2006). According to Walker (2000), up to 84% of the population will experience LBP at some point in their life. It is unknown, yet widely believed and indicated (O'Sullivan et al., 2011), if this LBP is related to passive sitting postures (O'Sullivan et al., 2002). Passive postures can be described as a tendency to rely on the bony structure and the ligamentous composition, instead of activating spinal muscles (O'Sullivan et al., 2002). Slumped sitting is a common passive sitting posture. It can be described as sitting with a posterior tilt of the pelvis with a relaxed thoracolumbar spine (Caneiro et al., 2010).

It has been suggested that slumped sitting has a negative effect on back stability (O'Sullivan et al., 2002). Slumped sitting has an effect on the active and the passive structures of the body. In a slumped sitting position a flexion relaxation of the thoracic muscles occurs. The flexion relaxation phenomenon is a sudden relaxation which appears in the long back musculature (erector spinae muscles) when sitting in a slumped position due to the prolonged stretch of the extensor muscles (Callaghan et al., 2002). The authors expected multifidus activity to increase to compensate for the relaxed long back muscles. Since no increase in multifidus activity was found, they suggest that the ligamentous and bony structure of the spine might take on the load of the body (Callaghan et al., 2006). These ligamentous structures (passive spinal stabilizers) are already affected by a stretch strain when being elongated for a short time as 20min (Solomonow, 2009). The creep occurring in the ligaments affect their capability as proprioceptors of the spine. This can impede the feed forward/feedback system states a review by Solomonow (2009). Spinal stability relies on a proper interaction of the active muscular, the passive (ligaments, spinal discs, bony structures) and neural control system (Georgy, 2011). The motor control system is the system in the brain which interprets afferent information (speed, trajectory, goal of movement) and uses it to perform a controlled movement. This controlled movement is engineered via specific muscle activation by the motor control system (Mazzoni et al., 2012). If the afferent information from ligaments and muscle spindles is incorrect, the motor performance of the body will be incorrect as well.

The opposite sitting position to passive slump sitting is active, upright sitting. In recent years, sitting on a gym ball instead of an office chair has become popular. Sitting on an unstable surface without a backrest was said to increase the amount of movements during sitting and muscular stability of the back (Kingma et al., 2009). An increase in back and core muscle activity was believed to increase spinal stability (Tesh et al., 1987).

Postural control is the ability to correctly align oneself above one's center of mass and depends on the correct interpretation of visual, vestibular, proprioceptive and nociceptive input (Massion, 1992). Radebold et al. (2001) confirmed that in sitting, patients with chronic idiopathic low back pain have an

increased postural sway compared to healthy controls. They suggest that there is a correlation between LBP and poor postural control (Radebold et al., 2001).

Postural control can be measured via body sway. Body or postural sway is the measurement of the movement of the center of pressure (CoP). The CoP is a fictional point which would appear if one tried to focus the weight distribution in one point under the support surface of a person (Ruhe et al., 2011). Postural sway occurs when a person tries to stabilize the body in an upright position above his center of pressure (Ramachandran et al., 2011). This active stability occurs via spinal and abdominal musculature in sitting. In standing, the leg musculature is also involved. It has been demonstrated that the activity of the back musculature decreases with a more flexed sitting position in comparison to an extended one (Dankaerts et al., 2006). Dolan et al. (2006) observed that slumped sitting reduces the spinal reposition sense when slumping for a short time as 5 minutes. They presume that this effect is caused by a disturbance of the proprioceptive control of the spinal stabilizers. Consequently, it would be logical to assume that if slumped sitting affects the proprioception of the spinal musculature (Dolan et al, 2006), reduces the activity of the stabilizing muscles (Dankaerts et al., 2006) and decreases spinal reposition sense (Dolan et al., 2006), it should also affect the postural sway.

Information on how postural sway is affected by short term slump sitting and active sitting can help physiotherapists give patients correct information on sitting positions. The results of this testing can be used in practice to work on correct sitting postures and postural stability. It can also help therapists organize a back friendly working schedule which might in turn help prevent low back pain.

It would therefore be interesting to see whether slumped sitting, a position often associated with low back pain, has an effect on the degree of postural sway in balancing afterwards. This will give an indication if passive postures (especially slump sitting) have prolonged effects on the ability to actively stabilize the body. This leads to the question if sitting postures affect the motor performance of the trunk. The following sub question appears also: Does short term slump sitting affect the amount of postural sway afterwards in a young, active adult compared to postural sway after active sitting?

It is hypothesized that there is a difference in the amount of postural sway after the sitting postures.

Methods

1. Study Design

This randomized controlled crossover study recruited 19 students (9 men and 10 women) from the Physiotherapy Department of Fontys University of Applied Sciences in Eindhoven via e-mail.

2. Subjects

In order to be included into the study, the student's age had to range between 18-35 years, they needed to be healthy subjects and 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. This choice was made to exclude the possibility of influences from back injuries on the research outcome. Other exclusion criteria were: vestibular disorders, any injuries or problems that impaired the subject's ability to walk and sit normally for a period of 40 minutes. Subjects allergic to glue or tape were excluded as well, since the co-author had to place surface EMGs on the subjects lower back.

3. Ethical Approval

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 given via the acceptance of the project plan (Appendix 4). The subjects were informed beforehand via an information letter (Appendix 2) and verbal instructions about the testing procedure and the handling of the personal data. All subjects decided to participate voluntarily in this study. The data was anonymized and only the researcher had access to it. The involved data and the intellectual property rights and claims were handed over to Fontys University of Applied Sciences (Appendix 6), who committed itself to a confidentiality statement (Appendix 5).

4. Research Procedures

4. 1. Preparation of the subject

The participants were informed about the testing procedure via oral information and an information letter. They were asked to sign an informed consent form (Appendix 1) before the start of the experiment.

Subjects were able to try out the testing instrument in order to get familiar with the testing devices and conditions. Depending on the height of the subject, the equipment (i.e. chair, gym ball) was adjusted to

achieve an approximate 90° hip/knee flexion angle. While trying out the equipment, the patient chose a foot on which he/she could stabilize better during the three following testing procedures. This was a personal choice and not influenced by the examiners. The testing position was practised for 1-2 minutes. To randomize the order in which the sitting positions were taken, subjects drew an envelope from a basket which contained a paper indicating either slump sitting or active sitting.

4.2. Sitting position

The sitting duration was chosen at 20 minutes slump sitting on a stool and 20 min active sitting on a gym ball. Studies have shown that there are very quick changes occurring on tissue level during slump sitting. Research has shown that the reposition sense is already significantly disturbed after 5 minutes of slump sitting (Dolan et al., 2006).

In general practice, sitting is a position that is taken up for a longer amount of time, for instance in office work. For this reason, the sitting duration was chosen at 20 minutes.

The sitting position on the stool and gym ball was adapted to the individual by placing boards under the feet to ensure a hip and knee angle of 90 degrees. For the slumped sitting position (Figure 2), 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.

For the active sitting position (Figure 1), subjects were instructed to keep their back upright. They were allowed to move their trunk and pelvis but should not support themselves with the hands on the legs or other objects. Again, the feet had to stay flat on the floor.



Figure 1: Active Sitting

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



Figure 2: Slump Sitting

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

Nowadays, office work is a common daily living situation. Therefore the subject sat at a table and watched a short movie on a laptop screen in 1 meter distance. In this build up subjects were instructed to focus only on the movie and not engage in other activities such as talking to the researchers or turn around to talk to other testing subjects at the gait lab. If subjects changed their sitting position drastically (i.e. slumped while in active sitting position, trunk rotation, crossed legs), they were reminded to sit slumped or active, respectively.

4.3. Active rest

Solomonow (2009) concluded that the spinal stabilizers need a 1:1 work:recovery ratio to prevent neuromuscular disorders when working less than 60min under static conditions. In addition, 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. The subjects consequently had a period of active rest for 20 minutes which ensured a 1:1 ratio with the duration of sitting.

Walking was chosen as an activity during the active rest period. Walking is a functional daily task that requires dynamic work of the muscles compared to static work during sitting. Subjects could choose their own comfortable walking speed on the treadmill.

4.4. Testing set up

Two conditions on the force plate were observed in this study. During the first condition, subjects were seated on a balance board. The balance board (radius of balance cone: 11,78cm; height: 6cm; radius of sitting surface: 26cm) was placed on top of the force plate. The force plate was placed near the edge of a table. The subjects could support themselves with the foot of their choice on an adjustable chair. This meant only the lumbar spine and the stabilizing foot could attempt to keep the body in equilibrium. The second condition was sitting directly on the mobile force plate with the feet hanging freely off the table. This measurement was chosen to simulate a normal sitting surface and prevent compensation via the legs.

To ensure that all subjects assumed the same arm position, the subjects were instructed to cross the arms in front of the body with their hands on the shoulders. Subjects were also asked to close their eyes as by excluding visual input, the body must rely more on the somato-sensory system (Madeleine et al., 2004). Any possible effects of the sitting positions on the somato-sensory system should be seen more clearly.



Figure 3: Balance board trial

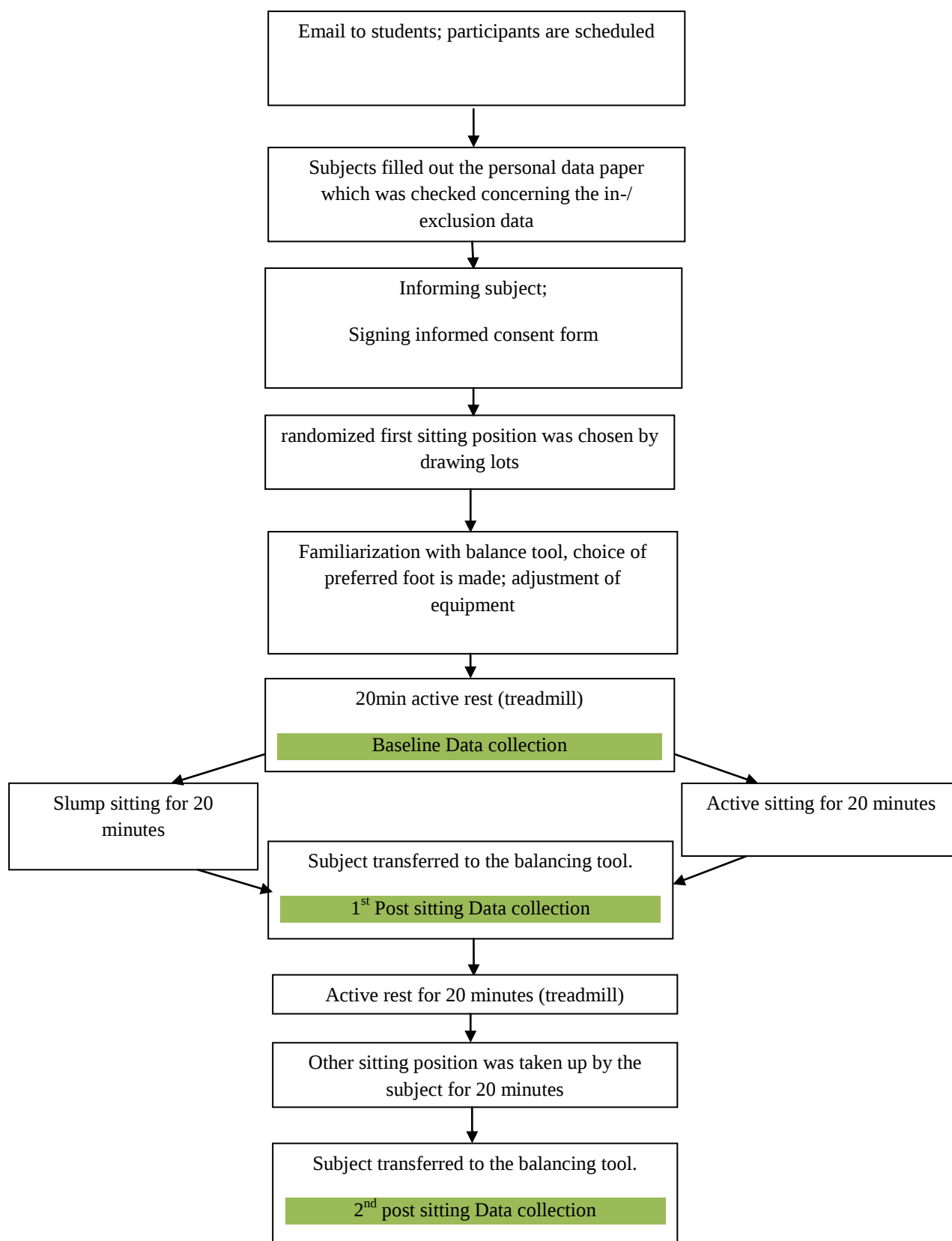
Subject sits on balance board, preferred foot stabilizes on the stool, eyes are closed, knees and hips are in approx 90°. Hands rest on opposite shoulders



Figure 4: Mobile force plate trial

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

Flowchart procedure:



5. Measurement Tool

An AMTI mobile force plate type OR6-7 (USA) was used together with the SYBAR 3.0 recording system. The data on position of center of pressure was recorded at 100Hz in meters in medial-lateral (X) and anterior-posterior (Y) direction.

6. Data Collection

Data was collected in two situations within the testing procedure. The first situation was balancing on the balance board with a straight back, closed eyes and one stabilizing foot. The second situation was sitting directly on the force plate with a straight back and the feet hanging freely.

The first set of data (baseline data) was collected after the initial treadmill walk. This data was used to compare a rested back condition to both sitting conditions later on. The second set of data was collected after the first sitting condition (i.e. slump or active sitting). The third and last set of data was collected after the second sitting position had been performed.

The software SYBAR 3.0 recorded the initial Forces in x,y and z direction, as well as Moment x,y and z. This raw data was inserted into Microsoft Excel 2010. Since during balancing the body will be in motion, it is important to not only know where the center of pressure (CoP) is positioned at a moment in time, but also how fast the CoP is moving (Reeves et al, 2011). For this reason sway in anterior-posterior, medial-lateral direction and total sway (combination of AP and ML sway) as well as velocity (AP, ML and total) and the distance the CoP travelled were calculated.

7. Data Analysis

The independent variables in this research were the sitting positions. The dependent variables were the amounts of sway and sway velocity after a sitting condition. The dependent variables were compared to baseline and the other sitting position. Sway was measured in X (ML) and Y direction (AP) by calculating the standard deviations in anterior-posterior and medial-lateral directions as well as the total sway (combination of AP and ML sway). Figure 5 shows a typical graph for center of pressure movement during a 60s interval after active sitting.

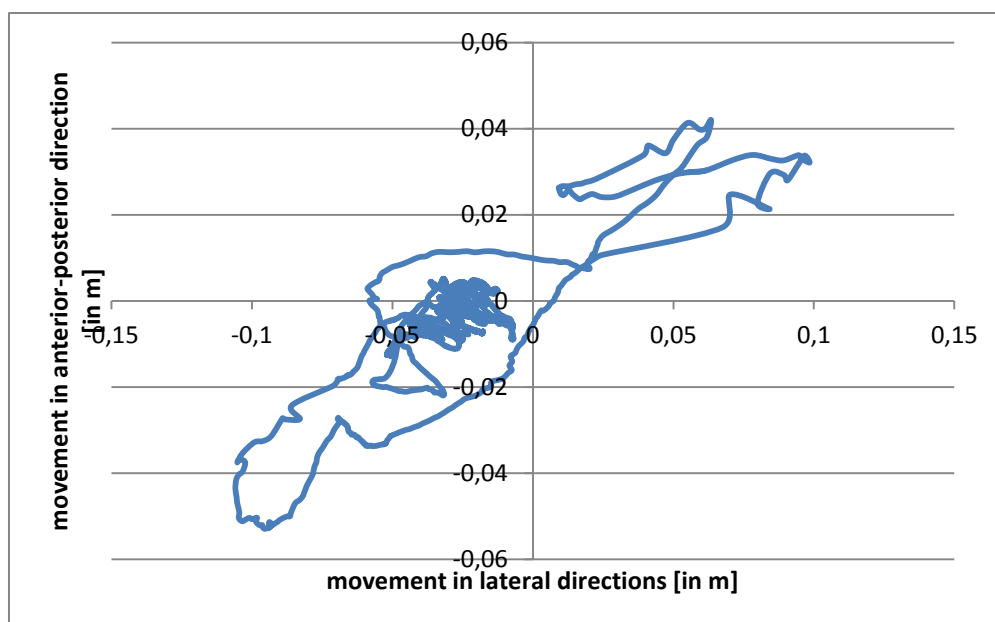


Figure 5. Center of pressure travel during a 60s interval after active sitting

Additionally, the mean velocities in ML, AP direction and vector velocity (combination of AP and ML velocity) were calculated in Excel. The total travelled distance of the CoP within the 60seconds of measurement was determined. A study by Salavati et al. (2009) concerning CoP measures in standing has shown that standard deviations in displacements and means concerning velocity measures have given high to very high retest reliability.

Next these data were imported into SPSS (Statistical Package for the Social Sciences). The version PASW Statistics 18 was used for analysis of the data. The data was checked for normal distribution by visual inspection and again via the Kolmogorov-Smirnov test. Data were found to be non-normally distributed. The median and interquartile range (IQR) of the data was collected. Nonparametric tests were further on chosen. To compare the different conditions to one another, the Wilcoxon Signed Rank test was used. The data post active sitting was compared to the baseline data, post slump sitting was compared to the baseline data and lastly post active sitting was compared to post slump sitting. These comparisons were made for both sitting on the balance board and sitting directly on the mobile force plate. The data was compared concerning the anterior-posterior, medial-lateral direction and total sway. To check if the outcomes of the tests were significant, a p value of $\alpha=0,05$ was chosen.

It was analyzed whether the order in which the sitting positions were performed had an influence on the amount of sway after the position had been assumed. The Mann-Whitney U test was chosen for this purpose.

Results

Because of measurement errors (different calibrations of the force plate), 8 subjects had to be excluded. 11 subjects (6 female, 5 male) with a mean age of 23,5 (+/-1,57) years and mean weight of 69,1 (+/- 10,1)kg were analyzed.

In the following section, first the results from the balance board testing and afterwards the results from the mobile force plate will be presented. To show the data distribution, all tables will present median and interquartile ranges.

1. Balance Board

Table 1 shows the balance board comparisons in medial-lateral, anterior-posterior directions and total sway. No significant differences were found ($p > 0,05$).

Table1. Balance Board Sway comparisons

Sway	Exact Significance (2-tailed)	Median and IQR (in m)	
ML post as vs. baseline	0,465	Baseline	0,0073 (0,0056-0,0106)
ML post ss vs. baseline	0,638	Post as	0,0069 (0,0047-0,0092)
ML post as vs. post ss	0,898	Post ss	0,0074 (0,0045-0,0095)
AP post as vs. baseline	0,765	Baseline	0,0031 (0,0024-0,0045)
AP post ss vs. baseline	0,638	Post as	0,0038 (0,0019-0,0047)
AP post as vs. post ss	0,365	Post ss	0,0025 (0,0020-0,0043)
Total post as vs. baseline	0,206	Baseline	0,0052 (0,0042-0,0069)
Total post ss vs. baseline	0,278	Post as	0,0040 (0,0022-0,0084)
Total post as vs. post ss	0,898	Post ss	0,0044 (0,0028-0,0064)

Calculated with the Wilcoxon Signed Ranks test (n= 11 subjects)

Post as= after active sitting; Post ss=after slump sitting; ML = medial-lateral direction; AP =anterior-posterior direction, IQR = interquartile ranges (25%, 75%).

In Table 2 the different velocities are compared for balancing on the balance board, again in ML, AP and vector velocity. Although all p values were found to be above 0,05, a trend can be seen of vector velocity to be less after active sitting compared to baseline measurement ($p=0,054$).

Table2. Balance Board Velocity comparisons

Mean Velocity	Exact Significance (2-tailed)	Median and IQR (in m/s)	
ML post as vs. baseline	0,084	Baseline	0,0184 (0,0125-0,0234)
ML post ss vs. baseline	0,413	Post as	0,0166 (0,0120-0,0202)
ML post as vs. post ss	0,700	Post ss	0,0171 (0,0123-0,0193)
AP post as vs. baseline	0,922	Baseline	0,0094 (0,0079-0,0106)
AP post ss vs. baseline	0,413	Post as	0,0092 (0,0077-0,0117)
AP post as vs. post ss	0,365	Post ss	0,0098 (0,0071-0,0115)
Vector post as vs. baseline	0,054	Baseline	0,0224 (0,0180-0,0266)
Vector post ss vs. baseline	0,206	Post as	0,0208 (0,0154-0,0239)
Vector post as vs. post ss	0,966	Post ss	0,0205 (0,0170-0,0227)

Calculated with the Wilcoxon Signed Ranks test (n= 11 subjects)

Post as = after active sitting; post ss = after slump sitting; ML = medio-lateral direction; AP = anterior-posterior direction; IQR = interquartile ranges (25%, 75%).

Table 3 presents the mean total distance of the center of pressure travelled by all subjects within one minute. While the total distance is almost the same between post slump sitting and post active sitting ($p=0,966$), post active sitting shows a trend towards decreased CoP displacement when compared to the baseline measurement ($p=0,054$).

Table3. Balance Board CoP travelled distance

Distance	Exact Significance (2-tailed)	Median and IQR (in m)	
Post as vs. baseline	0,054	Baseline	1,3422 (1,0820-1,5961)
Post ss vs. baseline	0,206	Post as	1,2494 (0,9260-1,4343)
Post as vs. post ss	0,966	Post ss	1,2305 (1,0203-1,3645)

Calculated with the Wilcoxon Signed Ranks test (n=11 subjects)

Post as = after active sitting; post ss = after slump sitting; IQR = interquartile ranges(25%,75%).

2. Mobile Force Plate

Sway in the different sitting positions in ML, AP and total sway were analyzed and the results shown in Table 4. All p values were found to be above 0,083. A non-significant difference could be found in sway in AP direction, showing less sway after slump sitting compared to the baseline measurement.

Table4. Mobile Force Plate Sway comparisons

Sway	Exact Significance (2-tailed)	Median and IQR (in m)	
ML post as vs. baseline	0,918	Baseline	0,0012 (0,0008-0,0018)
ML post ss vs. baseline	0,520	Post as	0,0012 (0,0010-0,0013)
ML post as vs. post ss	0,700	Post ss	0,0012 (0,0007-0,0017)
AP post as vs. baseline	0,278	Baseline	0,0028 (0,0016-0,0034)
AP post ss vs. baseline	0,083	Post as	0,0028 (0,0031-0,0049)
AP post as vs. post ss	0,765	Post ss	0,0022 (0,0015-0,0030)
Total post as vs. baseline	0,577	Baseline	0,0028 (0,0014-0,0032)
Total post ss vs. baseline	0,240	Post as	0,0019 (0,0014-0,0046)
Total post as vs. post ss	0,700	Post ss	0,0018 (0,0016-0,0030)

Calculated with the Wilcoxon Signed Ranks test (n= 11 subjects)

Post as = after active sitting; post ss = after slump sitting; ML = medial-lateral direction; AP = anterior-posterior direction; IQR = interquartile ranges (25%,75%).

Velocity was compared in the different sitting positions on the mobile force plate and shown in Table 5. No significances could be detected ($p > 0,32$).

Table5. Mobile force Plate Velocity comparisons

Mean Velocity	Exact Significance (2-tailed)	Median and IQR (in m/s)	
ML post as vs. baseline	0,320	Baseline	0,008 (0,0073-0,0087)
ML post ss vs. baseline	0,320	Post as	0,0068 (0,0060-0,0088)
ML post as vs. post ss	0,700	Post ss	0,0075 (0,0061-0,0089)
AP post as vs. baseline	0,520	Baseline	0,0111 (0,0106-0,0121)
AP post ss vs. baseline	0,577	Post as	0,0106 (0,0094-0,0107)
AP post as vs. post ss	0,765	Post ss	0,0107 (0,0081-0,0124)
Vector post as vs. baseline	0,320	Baseline	0,0152 (0,0141-0,0166)
Vector post ss vs. baseline	0,520	Post as	0,0134 (0,0128-0,0154)
Vector post as vs. post ss	1,000	Post ss	0,0157 (0,0129-0,0164)

Calculated with the Wilcoxon Signed Ranks test (n= 11 subjects)

Post as = after active sitting; post ss = after slump sitting; ML = medial-lateral direction; AP = anterior-posterior direction; IQR = Interquartile ranges (25%,75%).

Table 6 shows the mean total travelled distance of the center of pressure of all subjects within 1 minute. No significant differences were found. On the contrary, the travelled distance by the CoP is exactly the same between after active sitting and after slump sitting.

Table6. Mobile Force Plate CoP travelled distance

Distance	Exact Significance (2-tailed)	Median and IQR (in m)	
Post as vs. baseline	0,320	Baseline	0,9157 (0,8435-0,9959)
Post ss vs. baseline	0,520	Post as	0,804 (0,7688-0,9258)
Post as vs. post ss	1,000	Post ss	0,9414 (0,7749-0,9837)

Calculated with the Wilcoxon Signed Ranks test (n= 11 subjects)

Post as = after active sitting; post ss = after slump sitting; IQR = interquartile ranges (25%,75%).

3. The Influence of the Order of the Sitting Positions (Mann Whitney U tests)

Appendix 3 (page IV) gives the full table of the Mann Whitney U test, used to check the influence of the randomization process. No significant differences could be found between the two groups AS (active sitting first) and SS (slump sitting first). These outcomes concern both the balance board and the mobile force plate condition.

Discussion

The aim of this study was to answer the question if slumped sitting has effects on seated balancing in young, healthy people. Balance board data was obtained to gain information about balancing in a difficult situation, while sitting on the mobile force plate data showed how a subject balances on a fixed surface.

The results from this study showed that there is no significant difference between the amounts of sway in seated balancing after slump sitting in comparison to active sitting. Neither the amount of sway in anterior-posterior (AP) direction showed significances, nor in medial-lateral (ML) or total sway. Additionally, the velocities gave no indication of significant differences. This was in consensus with the personal experience of the subjects. Some subjects reported the balancing after slump sitting to be more difficult, others after active sitting, regardless of which position was acquired first.

Although p-values indicated no significant measures, examining the balance board measurements closely showed a difference in the velocity of the post active sitting only in ML direction to be lower than the baseline measurement (10% less speed). Similarly, the vector velocity for these comparisons was 7% lower for the active sitting and the total travelled distance by the CoP was 7% less for the post active balancing task. This might be an indication that subjects were sitting more stable after active sitting as compared to the baseline condition. No significances could be detected between the slump sitting and baseline measurements. Total sway and vector velocity after slump and active sitting were almost equal.

When sitting directly on the mobile force plate, the only difference which could be detected was the sway in AP direction being lower for post slump sitting compared to baseline measurement. No differences visible on the mobile force plate were equal to those on the balance board.

It was expected that there would be a difference in the AP sway of the subjects after slump sitting. The lumbar spine's ability to move is more pronounced in flexion/extension (anterior/posterior) than side-flexion. It is therefore logical, that this movement is more influenced than the medial-lateral movement as seen on the mobile force plate (baseline vs. slump sitting: AP: -21,4%; ML: 0%) and on the balance board (baseline vs. slump sitting: AP: -19,4%; ML: +1,4%). The stretch during slump sitting should have affected the erector spinae muscles more than the abdominal muscles. This and the fact that the influence of the erector spinae muscles is larger in the sagittal plane than other planes (Marieb, 2001), would also account for more differences in the AP movement. It was suspected that the amount of sway would increase after slump sitting due to proprioceptive disturbances of the passive structures. Instead it shows to be lower in both testing conditions, i.e. sitting on the mobile force plate and the balance board (only ML sway increase by 1,4% on the balance board) compared to baseline measurements. One reason for sway decrease could be that after slump sitting, in order to protect the spine, the subjects stiffened the spine against more movement. However, this would only account for the decrease of sway on the fixed surface, since Reeves et al. (2006) show that increased trunk stiffness results in more sway on an unstable surface. Low back pain subjects have been found to use

this exact strategy (involuntarily) to stabilize the spine more effectively (Cholewicki et al., 1996). In accordance, the co-researchers electromyography data showed a significant increase in activity of the iliocostalis lumborum after both slump and active sitting on the mobile force plate compared to baseline measurements (Ebert, 2013; unpublished data).

Van Dieen et al. (2010) found similar results regarding subjects who recently (no current pain but LBP episode within last 12 months) had LBP and control subjects sitting on an unstable surface. Recent LBP patients exhibited less sway in AP direction than control subjects. They suggest that the decreased postural sway results from exhibiting more effort concerning the stabilization task than the controls. Although the participants of this study were all healthy, young subjects, most subjects reported the feeling of discomfort, slight back pain and a need to stretch their back after 20min of slump sitting. This feeling did not occur after the active sitting period. It could be due to the sitting position itself and the instructions of not moving at all while sitting slumped. In occupational settings, for example students and software programmers, sitting for longer periods occurs quite frequently. To mimic such a task and achieve any possible effects from slump sitting, the subjects were asked not to change their position during slumping. They were also asked to refrain from stretching until after the balancing measurements had been taken. The subjects from this study cannot be compared to the chronic low back pain patients used in most studies (for example Radebold et al., 2001) but it may be possible to relate their performance to that patient who recently had low back pain. Their short pain episode unlike that of chronic LBP patients may not have given rise to adaptations such as different muscle recruitment patterns (Van Dieen et al., 2003), sitting positions (Dankaerts et al., 2006) and muscle latency periods (Radebold et al., 2001).

One possible explanation for the insignificant differences between post slumped and post active sitting sway on the balance board and the mobile force plate may be that not only one but both sitting positions had a negative influence on spinal stabilization. Sitting slumped has shown to influence the spine by increasing the load on the passive tissues (Callaghan et al., 2002). It was therefore hypothesized that there would be a difference between post active and post slump sitting; however, this was not found. The differences which could be seen were between baseline and active sitting on the balance board and baseline and slump sitting on the mobile force plate. Thoracic upright sitting (slight retraction of scapulae, extension of thoracolumbar spine) which is similar to this study's active sitting position has shown to increase the muscular activity of the internal and external abdominals as well as thoracic erector spinae and iliocostalis pars lumborum (O'Sullivan et al., 2006). Reeves et al. (2006) assessed that an increase in muscular back activity (lumbar and thoracic erector spinae) during balancing, as expected after active sitting, results in a poorer postural control and increased sway velocity. Moreover, a study by O'Sullivan et al. (2013) showed that sitting on an exercise ball can result in muscle fatigue and spinal shrinkage via compression of the spinal discs. It can consequently be suggested that both sitting positions had an impact on different spinal components and the stabilizing effect of the spine. If both sitting positions influence spinal stability, it would explain why there is no difference between sway and velocity after the two sitting positions.

If both sitting positions had an influence on the spinal stability, then there should be a significant difference between the post active and slump sitting measures compared to the baseline measurement. One reason for the fact that there is no significant difference between sway after slump sitting and sway baseline on the balance board could be related to the experiment set-up. Subjects were able to stabilize with one foot on a chair. This chair was adjustable to get an approximate 90 degree hip and knee angle for each subject. These degrees were chosen to closely represent the normal office chair sitting positions acquired in daily life. Cholewicki et al. (2000) state, that in sitting the postural control of the lumbar spine is independent of the control of the lower limb. Although the control of the lumbar spine positioning is independent, the posture and the center of pressure of the body should still be influenced by movements and stabilizing efforts of the lower limb. Excluding postural correction via the lower limb such as in Cholewicki et al.'s study would have increased the difficulty to stabilize but completely erased a possible stabilizing effect via the lower leg. The researcher of this study deemed sitting without foot support on the balance board too difficult without a long practice period. By testing also on the mobile force plate without foot support, the author tried to eliminate the effect of the stabilizing foot. However, there was no consensus in the changes of sway (less AP on mobile force plate after slump sitting, less ML on balance board after active sitting). Another reason for the insignificant results could be the activity the subject performed before taking part in the experiment. All subjects began by resting actively on the treadmill for 20min. This active rest was chosen to gain a similar rested back condition for all subjects. The researcher was, however, unaware of the subjects activities previous to the experiment which might have had a lasting influence on the spine.

Static lumbar flexion has shown to have effects on the muscles and ligaments of the lumbar spine. Solomonow (2009) states that although a 1:1 work:recovery schedule is optimal to prevent neuromuscular disorders in a person, it is too little time to eliminate the full creep of the ligaments. Creep of ligaments can be explained as an elongation of the ligament to its maximum length and if kept in a stretched position, it will continue to lengthen, although more slowly for as long as it is kept under stress (Solomonow, 2009). Ligaments recover within the first hour only 40-60% from this creep. It can therefore be expected, that the residual creep in the subjects sitting slumped first, also affected the active sitting stability later on.

Not only the passive but also the active components of the spine play a role in proprioception. Reeves et al. (2011) proposes that muscle spindles play a much higher role in tracing the movements of the spine. Muscle spindles can detect not only position changes but also velocity changes (Marieb, 2001). Therefore muscle spindles can detect more accurately where the spine is positioned, how fast it is moving and how to counterbalance this movement (Reeves et al., 2011). Georgy (2011) suggests that increased muscle stretch interferes with correct afferent impulses which in turn give the body incorrect feedback control mechanisms. Consequently, decreased proprioception and motor performance were expected. Although the muscles of the back (lumbar and thoracic erector spinae) were kept in a stretched position for 20min during slump sitting, no difference was seen in the subject's ability to balance afterwards. In relation to the spinal muscles, a reason could be that according to Cholewicki

and McGill (1996), for light stabilizing activities of the back, the multifidus muscle must only contract to a 1-3% maximal voluntary contraction to ensure a stable back. Reeves et al.'s (2006) experiment showed that a 4% MVC contraction of the lumbar and thoracic extensors is sufficient to balance on an unstable seat. While in this study static lumbar flexion may have influenced the proprioception, it may not have diminished the muscles' capability to stabilize at this low level contraction. Jackson et al. (2001) tested 20min of passive flexion of the spinal muscles of a cat and then concluded that even after seven hours; the muscles had not fully recovered from the muscular strain. It can therefore be suggested that for subjects who slumped first, the muscle stretch and ligament stretch influenced the proprioception of the post active sitting stability as well. As the study population was quite small (five versus six subjects), no significant differences (balance board $p=0,247$; mobile force plate $p=1,00$) could be found when evaluating the results for differences according to which sitting position was acquired first (Mann Whitney U test).

Another explanation for the non significant findings between sway after slump sitting and baseline measurements is offered by Brumage et al. (2004). They investigated that when one proprioceptive area is damaged, the central nervous system can shift its focus to a different body part and retrieve the necessary proprioceptive information from there. Moreover, since the body does not only receive proprioceptive information, visual and vestibular input has to be taken into account as well. While this experiment eliminated visual input, there was still the possibility to compensate for a possible decrease in proprioception in the lumbar spine area via input from the vestibular organ and the proprioceptors of the lower limb. This means there could be a difference in proprioception of the lumbar area after slump sitting which cannot be detected in this experiment due to the central nervous system receiving information concerning position from areas without disturbed sensors.

It was chosen to not include a secondary task due to the difficulty of the balancing task. It has already been investigated that in dual task experiments the postural stability and the muscular responses diminish (Rankin et al., 2000). When the person's attention focuses more on the cognitive task, less attention capacity is left for the postural stability. Van Daele et al. (2010) came to the same results with healthy subjects in sitting position as Rankin et al. (2000) in standing. It is a logical outcome when remembering that postural stability is influenced by somatosensory, vestibular and visual components (Van Daele et al., 2010) which have to constantly be evaluated and processed. If the cognitive capacity of the brain is geared toward a secondary task (e.g. a simple computer game), the subject will be distracted (less attention is geared towards the posture) and the visual input may also have an influence on the outcome of the testing. By making balancing a cognitive process, it may be that the subject was able to overcome any effects the slump sitting might have had on the proprioception of the spine.

To explain the non-significant outcomes, attention must also be geared towards the learning effect. The study by Van Daele et al. (2007) studied the reproducibility of measuring postural control in sitting on a balance board with one foot stabilizing on the floor. They assessed this set up to be of moderate reproducibility and advise a learning period at the beginning of the testing. Cholewicki et al. (2000) propose a try out period of one minute for their experiment. Although this study did take a learning

period of 1-2 minutes into account, subjects sat only once on the balance board and tried it out until they felt they could stabilize the board. The try-out period was mainly used to establish which foot will be used to help stabilize during the actual experiment. Since the amount of total sway decreased after baseline measurements (for both balance board and mobile force plate conditions), it seems logical that there was a learning curve. The Mann Whitney U test shows that all differences between balancing after slumped/active sitting were insignificant ($p > 0,083$) regardless of which position was acquired first. Since there was an almost equal distribution among the groups (five versus six subjects), the baseline balancing seems to have been enough time to create a familiarization with the balance board. The learning effect would explain why subjects seemed to sit more stable after active sitting on the balance board than during the baseline condition.

Strengths and Limitations

To the knowledge of the researcher, no study has so far investigated the effect of different sitting positions on postural stability afterwards. Many studies have researched the direct effect of sitting postures on muscle activity (O'Sullivan et al., 2006; O'Sullivan et al., 2002) and repositioning of the spine (Georgy, 2011; Dolan et al., 2006). However, concerning sway in sitting, most studies used LBP patients and healthy controls. This study chose to research the effect sitting postures have on the motor control of a healthy spine in a young adult. It can therefore help physiotherapists give correct sitting instructions for back pain prevention.

The study originally included 19 test subjects. Due to measurement errors by the force plate and calibration errors, the measurements of eight subjects had to be discarded. Due to time management problems, no new tests could be run. A larger group of participants should have been observed to gain more significant results. Since already a few insignificant differences can be observed, there is a great possibility of these differences to be significant in a larger study population. Van Daele et al. (2007), for example, included 16 subjects and Callghan et al. (2002) examined 22 subjects.

One limitation of this study was that the subjects were trying to stabilize themselves with one foot positioned on an adjustable chair. This chair was rotating sometimes slightly during the balancing reactions of the subject. Some subjects ended up having rotated almost 45 degrees after the minute of measuring. This will have influenced the medio-lateral and anterior-posterior measurements. The rotation can be seen as a weak point in the set-up of the experiment and probably had a negative effect on the results. It would be wise to use the set up of Cholewicki et al. (2000) during further research. They implemented a foot support which was attached to the balance board, so the pelvis and lower limbs moved in unison. This foot support would completely erase the stabilizing influence of the lower limb. Furthermore, this set-up would take Brumagne et al.'s (2004) explanation of proprioceptive information weighing into account, since it will not be possible to retrieve reliable information from the ankle/knee joints.

Another limitation was the choice of the dynamic sitting position. Research has shown recently that sitting on an exercise ball does not have positive effects on the spine (O'Sullivan et al., 2013). A

different sitting position may have given different results. For example, Van Dieen et al. (2001) suggest sitting on a dynamic office chair with a back support may decrease tissue loading. Also, many subjects did not move a lot while sitting actively. They kept their back mostly in an upright, rigid condition. Only two subjects frequently moved their pelvis and trunk to shift the load. So instead of sitting dynamically, most subjects maintained a static posture.

A further problem was the correct calibration of the force plate. The current data gave unusually high data for the subject's weight. According to the force plate data, all subjects weighed over 1000N (100kg). Since this data was needed to calculate the current position x and y on the force plate, it may have interfered with the results. Another factor concerning the force plate measures was the level of noise in the gait lab. While taking the measurements, there were other people walking around in the gait lab, causing the subject to shift attention towards these people. No trials were excluded even if the subject lost balance and needed to be stabilized by the researcher. This may have been a confounding factor, since extreme data values were not excluded from the data set.

Recommendations for Future Research

Brumagne et al. (2004) suggest that their explanation of a shift in the area of sensory input used by the central nervous system to maintain balance may only be applicable in easy tasks (such as balancing only). Further research could show if inclusion of a secondary task during balancing might give more significant results.

Although there was in this study no significant difference concerning length of CoP trailed path, Van Dieen et al. (2010) measured that there is a difference in sway frequency between healthy subjects and low back pain patients. They conclude that patients with LBP react infrequently with larger changes while healthy subjects react to balance perturbations with small, frequent movements. Future research should therefore take the frequency of movements into account.

Clinical Implications

This study has shown that postural stability is not affected significantly by sitting postures; therefore no conclusion could be made concerning proprioceptive disturbances of the lumbar spine. Both sitting postures resulted in almost exactly the same amount of sway and velocity in seated balance afterwards. The most important result from this study is therefore that the overall motor performance of the body during seated balance cannot be influenced significantly by sitting postures. In accordance with current research no one posture can be deemed to be the best posture (O'Sullivan et al., 2012). Concerning physiotherapeutic education of patients' sitting positions, this study consequently advocates not teaching one specific sitting posture but rather the frequent changes of posture allowing for a change in tissue stretch/compression. No conclusive advice can be given concerning sitting positions and back pain prevention. However, it may be of interest to practice sensory integration to let the patient experience where and how tissues are reacting to stretch and compression and change

sitting postures according to these sensations. As the subjects mostly presented with slight discomfort of the lower back after slump sitting, it might also be advisable to show a few exercises to stretch the back after a period of prolonged sitting.

Conclusion

No significant differences could be found concerning sway and velocity changes in postural stability after slump and active sitting. This means the motor performance did not change significantly. Further research is necessary to confirm that slump sitting does not affect the proprioception of the lumbar spine significantly or if the insignificances are due to compensation mechanisms of the body and limitations in the experimental design of this study. The outcomes of this study do not allow making any assumptions concerning sitting positions and low back pain prevention.

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Appendices

Appendix 1: 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 2: Letter of Information

Motor control of the trunk – Information letter

Dear student,

We (Leonie and Theresa, 4th year students English Stream Physiotherapy) would 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 the 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 did not have any past or present back complaints for which you received physiotherapy during the last 2 years 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 will not 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 decode 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

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Appendix 3: Mann Whitney U Tests

No significant differences were seen in sway, velocity or CoP travelled distance concerning the order of the sitting positions before testing. In fact, a few outcomes show that sway was exactly the same ($p=1,00$). This accounts for both balance board data and mobile force plate data.

The following Table 7 presents the exact significance, the median and the interquartile ranges for balancing on the balance board.

Table7. Balance Board Mann Whitney U tests

Condition	Exact Sig.(2-tailed)	Median and IQR (in m)
Sway ML post as	1,00	AS 0,0069 (0,0041-0,0121) SS 0,0071 (0,0046-0,0133)
Sway AP post as	0,662	AS 0,0040 (0,0022-0,0063) SS 0,0029 (0,0016-0,0057)
Total Sway post as	0,792	AS 0,0040 (0,0031-0,0088) SS 0,0035 (0,0020-0,0098)
Sway ML post ss	0,329	AS 0,0052 (0,0043-0,0155) SS 0,0081 (0,0066-0,0125)
Sway AP post ss	0,792	AS 0,0028 (0,0019-0,0054) SS 0,0023 (0,0019-0,0050)
Total Sway post ss	0,247	AS 0,0031 (0,0024-0,0103) SS 0,0049 (0,0040-0,0073)
Mean Velo ML post as	0,662	AS 0,0185 (0,0123-0,0218) SS 0,0144 (0,0115-0,0304)
Mean Velo AP post as	0,329	AS 0,0101 (0,0087-0,0124) SS 0,0081 (0,0072-0,0151)
Mean Vector Velo post as	0,429	AS 0,0217 (0,0184-0,0262) SS 0,0180 (0,0149-0,0361)
Mean Velo ML post ss	0,082	AS 0,0123 (0,0103-0,0337) SS 0,0181 (0,0170-0,0293)
Mean Velo AP post ss	1,00	AS 0,0074 (0,0069-0,0150) SS 0,0086 (0,0074-0,0123)
Mean Vector Velo post ss	0,082	AS 0,0170 (0,0143-0,0381) SS 0,0221 (0,0204-0,0331)
Total Distance post as	0,429	AS 1,3025 (1,3025-1,5712) SS 1,0790 (0,8940-2,1680)
Total Distance post ss	0,082	AS 1,0203 (0,8590-2,2870) SS 1,3237 (1,2268-1,9855)

Calculated with the Mann Whitney U test (n=11 subjects; 6 SS, 5 AS)

Post as = after active sitting; post ss = after slump sitting; AS = active sitting first; SS = slump sitting first; Velo = velocity; IQR = interquartile ranges (25%, 75%); Vector = combination AP and ML movement

Table 8 presents the data distribution of the subjects who sat in an active sitting position or slump sitting first and shows via the Mann Whitney U test that there is no significant difference between the groups concerning sway, velocity or the distance the CoP travelled during 60seconds.

Table 8. Mobile Force Plate Mann Whitney U tests

Condition	Exact Sig.(2-tailed)	Median and IQR (in m)
Sway ML post as	0,429	AS 0,0013 (0,0011-0,0023) SS 0,0011 (0,0010-0,0013)
Sway AP post as	1,00	AS 0,0021 (0,0012-0,0048) SS 0,0016 (0,0014-0,0055)
Total Sway post as	1,00	AS 0,0020 (0,0012-0,0045) SS 0,0017 (0,0014-0,0053)
Sway ML post ss	0,662	AS 0,0009 (0,0006-0,0017) SS 0,0013 (0,0008-0,0017)
Sway AP post ss	0,792	AS 0,0022 (0,0016-0,0033) SS 0,0020 (0,0013-0,0036)
Total Sway post ss	1,00	AS 0,0018 (0,0016-0,0033) SS 0,0021 (0,0014-0,0035)
Mean Velo ML post as	0,792	AS 0,0066 (0,0060-0,0104) SS 0,0070 (0,0062-0,0091)
Mean Velo AP post as	0,537	AS 0,0096 (0,0086-0,0133) SS 0,0105 (0,0095-0,0125)
Mean Vector Velo post as	0,537	AS 0,0130 (0,0117-0,0187) SS 0,0137 (0,0130-0,0172)
Mean Velo ML post ss	1,00	AS 0,0075 (0,0056-0,0091) SS 0,0076 (0,0071-0,0080)
Mean Velo AP post ss	1,00	AS 0,0107 (0,0080-0,0133) SS 0,0110 (0,0075-0,0126)
Mean Vector Velo post ss	1,00	AS 0,0160 (0,0109-0,0168) SS 0,0150 (0,0137-0,0167)
Total Distance post as	0,537	AS 0,7816 (0,6993-1,1226) SS 0,8218 (0,7828-1,0334)
Total Distance post ss	1,00	AS 0,9544 (0,6511-1,0051) SS 0,8974 (0,8212-1,0007)

Calculated with Mann Whitney U test (n= 11subjects; 6 SS, 5 AS)

Post as = after active sitting; post ss = after slump sitting; AS = active sitting first; SS = slump sitting first; Velo = velocity; IQR = interquartile ranges (25%,75%); Vector = combination AP and ML movement

Appendix 4: Project Plan Approval

B4 Assessment form project plan

Name: Leonie von Hagen

Student no:

Date: 3-2-2013

Title: slump sitting motor performance

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 yes
- The product requirements are accurately described yes

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

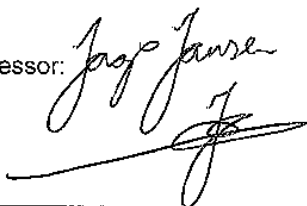
Comments: The project plan is quite extensive and pretty well written. I do have confidence that it can be a success! However, you still need to work out the comments that I asked in the project plan before you can really start with data collection. This will not be a lot of work....

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

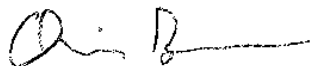
Name assessor:



Date + Signature

18-2-2013

Chris Benthien



Appendix 5: Confidentiality Statement

Name: Leonie E. Von Hagen

Student No°: 2146044

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

Does short term slump sitting affect the amount of postural sway in a young, healthy adult?

Content (description):

Background Information: Slumped sitting has been associated with low back pain. Low back pain has shown to affect postural stability. In the lower back of a healthy person, little is known about the effects slump sitting has on motor control and sway.

Objective: To investigate if there are differences in the amount of sway and sway velocity after a period of slump sitting compared to a period of active sitting.

Research Question: Does short term slump sitting affect the amount of postural sway in a young, active adult?

Study Design: Randomized controlled crossover study.

Methods: 11 healthy, active subjects were asked to sit for 20 minutes in a slumped position on a backless chair and 20 minutes in an upright position on a gym ball. At the start and between the sitting positions, they were asked to walk for 20 minutes. Measurements were obtained via a force plate at baseline and after each sitting position. Subjects sat on a balance tool and directly on the force plate for 60 seconds each during data collection.

Results: No significant differences could be found. Small, though non-significant decreases of sway in medial-lateral direction, path travelled by the center of pressure and vector velocity were found on the balance board only between active sitting and baseline. On the mobile force plate, only slump sitting compared to baseline showed a non-significant decrease in sway in anterior-posterior direction.

Conclusion: The findings suggest a non-significant influence of both sitting postures on sway and sway velocity. This implies that physiotherapists should not teach one specific sitting position but rather frequent changing of posture.

Key Words: slump sitting, postural sway, proprioception, low back pain, stability, seated balance, motor control.

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:

Name: Leonie von Hagen

Leonie von Hagen

(signature)

Date: 30/05/2013

Supervisor:

Name: Jaap Jansen

(signature)

Date: __/__/____

Coordinator: for receipt

Name: _____

(signature)

Date: __/__/____

Appendix 6: Conveyance of Rights Agreement

AGREEMENT

Pertaining to the conveyance of rights and the obligation to convey/return data, software and other means

The undersigned:

1. Ms. Leonie Elisabeth von Hagen, 5642 NH Eindhoven, Tongelresestraat 398, 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: Leonie von Hagen

Name: _____

Leonie von Hagen

(signature)

(signature)

Date: 30/05/2013

Date: __/__/____

Place: Eindhoven

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]