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Physiotherapy English Stream

The effect of locus of breathing on balance

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Preface

This research report is the final test of my physiotherapy education. Of course there is still more to learn once I have received my diploma. Physiotherapy with all its specializations, is a very broad discipline and offers quite a variety to its practitioners. Oppositely, there are also opportunities for its practitioners to broaden the field even more, by forming, testing and implementing new theories. Fontys University of Applied Sciences and more specifically my thesis supervisor, have given me this opportunity as well. The intervention I studied was quite unheard of within physiotherapeutic fall prevention. I would like to thank my thesis supervisor for allowing me to choose my own topic and letting me explore these new grounds. This greatly benefited my motivation as well, because it is so much easier to put months of effort into a project, when you are genuinely interested in the topic. Additionally, I can only be grateful for the excellent and elaborate supervision provided by my supervisor throughout the project.

Furthermore, I would like to thank my parents and fellow students, for their sincere interest and advice. I received exceptionally much help from a number of students, without whom the experiment could never have been executed. Therefore, thank you to the participants and my ‘assistants’, who all sacrificed much of their time, which has been a scarce and valuable treasure these past months.

Enjoy reading the product of the combined efforts of all these people and myself. I hope that you appreciate reading about an intervention which has rarely been considered in the context of physiotherapeutic fall prevention.

Abstract

Introduction: This study investigates a potentially new tool for physiotherapeutic fall prevention in elderly, namely Abdominal Breathing (AB). A previous study has indicated better stability with AB than Thoracic Breathing (TB) in young healthy individuals. So far clinical relevance has been limited, because Normal Breathing (NB) was not included and because tasks were not sufficiently challenging to provoke and measure falls (or less extremely, failure to maintain posture).

Objective: Specifically, this study aimed to determine whether AB improves balance performance compared to NB and TB, in challenging balance conditions.

Method: A randomized cross over experiment was performed, balanced for sequence and carry-over effects, to measure and compare effects of AB, NB and TB on balance. Twelve healthy, young physiotherapy students were recruited by mail. Subjects performed three Balance Error Scoring System (BESS) series for each breathing pattern. Outcome measures were BESS scores, number of trials in which steps/falls occurred and six center of pressure parameters (obtained with a force plate). The first two outcome measures were obtained on basis of a video recording. Data was analyzed using SPSS and with 20 dependent variables, the Bonferroni adjusted significance level was set at P = 0.005.

Results: No significant differences or trends were found between the breathing patterns.

Conclusion: The results suggest that AB does not offer significant protection in situations in which balance is challenged.

Itinerary

Introduction

Many elderly people (aged 65 and older) are faced with the fear and consequences of falling. Falls are indeed prevalent in this part of the population; in one Dutch study, 31.6 % of elderly subjects reported a fall and 14.8 % reported multiple falls having occurred in the preceding year.[1] Being responsible for 84 % of injury related hospital admissions in a study by Peel et al., falling appears to be the leading cause for injury in older adults.[2]

In the same study, more injurious falls in elderly occurred at home (55.2%) than in residential institutions (27.2%).[2] Nevertheless, the actual risk of such a fall appeared to be higher for institutional care residents.[3-5] With respect to age and sex, in a Canadian study prevalence of fall related admissions in elderly increased with age and was twice as high for females as for males.[6] Another risk factor identified by some studies is postural sway as measured by Centre of Pressure (CoP) displacements.[7-8] Postural sway is the movement of a person's Centre of Gravity relative to the supporting surface. The CoP in this context, is the point through which the resultant force of a body passes through this surface.[9] Evidence has suggested many more risk factors, including bilateral vestibular hypofunction[10], certain visual deficits[11], medication[12-13], reduced proprioception and cutaneous sensation[14], lower limb weakness[7] and cognitive impairment[3].

Subsequent to a fall, victims are often left with injury, reduced function, limited participation and occasionally death.[16, 2] In a study by Stel et al. on falls in the elderly, 68.1 % resulted in physical injury, 17.2 % required medical treatment and 5.9 % caused severe injury comprising fracture, joint dislocation or brain injury.[16] Following their last incident, many remained limited functionally (35.3 %), socially (16.7 %) and physically (15.2 %).[16] Peel et al. even found a fatality rate of 5.2 %.[2] In the Netherlands, these injuries account for € 474.4 million (20.8 %) of annual health care costs.[17]

Fall prevention deserves our attention and no doubt additional means on top of the already existing ones are more than welcome. From a physiotherapeutic perspective, an important sub-goal in the fall prevention process is balance improvement. For this end, one potential approach has not yet been thoroughly considered. That is: Abdominal Breathing (AB). Characteristic for this type of breathing is that respiratory volume excursion is predominantly accounted for by abdominal expansion, whereas in Thoracic Breathing (TB) it is mainly the thorax that expands. Eastern martial arts and Zazen Buddhism have long advocated AB, and ascribed various benefits to it, including improved balance. Experimental data reveals possible mechanisms to support this hypothetical effect. For example, AB has been shown to result in greater diaphragmatic excursion than TB[18], pushing the bowels further inferiorly[19] and thus lowering the body's Centre of Gravity (CoG). Additionally, AB appears to result in higher intra-abdominal pressure[18], which in turn increases lumbar rigidity[20]. Possibly, a lower CoG and a more rigid spine could offer some protection from destabilizing forces, thereby facilitating postural stability. Research by Hodges et al. also suggested that diaphragmatic activity plays a postural role.[21] Conclusively, AB deserves consideration as a balance improving tool.

Hamaoui et al. already investigated the effects of AB and TB on CoP measures of postural stability, in normal non-challenging sitting and standing positions. They found significantly smaller AnteroPosterior (AP) amplitudes of the CoP (indicating greater stability) in AB compared to TB.[22] However, the currently available research does not provide a sufficient link to fall prevention: Firstly, AB has not yet been compared to Normal Breathing (NB), which would bear more direct clinical relevance. Secondly, falls or (less extremely) failure to maintain posture have not previously been provoked and measured. This research will attempt to make up for these shortcomings, to help determine whether or not AB could contribute to the array of physiotherapeutic fall prevention methods for the elderly.

For the above mentioned reasons, the aim of this study is to more elaborately determine whether AB improves balance performance compared to NB and TB, in challenging balance conditions.

Method

Aim and study design

This was an intervention study with a randomized crossover design, aiming to compare the effect of AB, NB and TB on balance. Each participant received identical interventions and only the sequence of interventions differed. The design was balanced for sequence and carry-over effects, i.e. an equal amount of participants was assigned to all six possible intervention sequences (by drawing pieces of paper from a bag).

Subject recruitment

A recruitment e-mail was sent to all students from a physiotherapy programme in Eindhoven, the Netherlands. An informed consent form was signed before the experiment (Appendix I). Inclusion criteria were: scholarship at the school in question and being generally healthy. Exclusion criteria were respiratory disorders; operation on the lower limb, back, abdomen or thorax in the past 6 months; significant impairment of the lower limb, back, abdomen or thorax and finally; balance disorders or medication known to affect balance.

Measurement tools

Two tools were used simultaneously for balance measurements: the Balance Error Scoring System (BESS) test and force plate posturography to derive CoP displacements. They were applied in all three conditions: AB, NB and TB. The BESS is a method to measure imbalance by counting the occurrence of predefined errors as the subject performs three testing positions (double leg, single leg and tandem stance) on two different surfaces (firm ground and foam pillow). Consequently there are six trials in total per BESS series (see Appendix II for the six stances). In each trial the respective stance has to be maintained for twenty seconds with eyes closed. According to the BESS, an error is ascribed in each of the following events: hands lifting of the iliac crest; opening the eyes; a step, stumble or fall; hips moving into more than 30º abduction or flexion; lifting of forefoot or heel and finally; remaining out of the testing position for more than 5 seconds. In case multiple errors occur simultaneously only one error is ascribed. Maximum error score is ten per trial and thus sixty for a whole series of six trials. In the event a subject begins to fall, an assistant is nearby to help him/her regain balance and re-assume the testing position. Also, subjects are told to open their eyes and do whatever necessary to regain stability whenever balance is lost.[23-24]

The second tool: force plate posturography, was simultaneously used to measure performance during the BESS trials. In the three "firm ground trials", subjects were standing directly on the force plate and in the three "foam trials" on an overlying foam pillow.

Measurement Protocol

The experiment was conducted in a gait lab, at the institute from which the students were recruited. To improve time efficiency, two subjects were present at a time, allowing one to be tested during the breaks of the other. During the measurements the subject was always positioned on the force plate. For CoP measurements an AMTI mobile force plate type OR6-7 (USA) was used, measuring 46 x 50 cm. Output was recorded using the SYBAR 3.0 recording software, at a sampling frequency of 100 Hz. The foam pillow was an AIREX Balance-pad measuring 41 x 50 x 7 cm. Only an assistant was standing by the subject's side to provide support when needed. Camera footage was made for more reliable BESS evaluation, using a digital HD video-camera. In all trials except for the tandem stance, subjects were filmed directly from the front. For the tandem stance, subjects had to turn 45° in order to fit both feet on the force plate. This rotation was accounted for in the calculation of CoP parameters.

Subjects were informed of the purpose of the experiment, while care was taken not to communicate any expectations concerning the effectiveness of any of the breathing patterns. Before the measurements, subjects were first familiarized with the three patterns. For abdominal breathing, they were instructed to inhale by expanding the abdomen and exhale by reversing the expansion, with minimal participation of the thorax. Conversely, for thoracic breathing they were instructed to inhale by expanding the thorax and exhale by reversing the expansion, with minimal participation of the abdomen. For normal breathing, they were asked not to pay attention to their breath, and simply breath as they would normally. Additionally, it was emphasized for safety and research purposes that they were not supposed to hyper- or hypo-ventilate in any way. For every breathing pattern, five minutes were reserved for instructions and practice directly before it was performed during the balance tests. Participants were asked to continue the prescribed breathing pattern throughout every series and to resume practicing every time the other subject was halfway his series.

The experiment was conducted in accordance with the description of the BESS test provided earlier. Before testing, subjects were informed about the scoring system. Three BESS series were executed consecutively for the first breathing condition, followed by an equal amount of BESS series for the second and third conditions. In a study by Broglio et al., calculating the average of three test repetitions was indicated for acceptable reliability (a G coefficient of 0.81 for males and 0.79 for females).[23] The order of the three conditions was randomly determined.

Outcome measures

For each breathing pattern (AB, TB and NB), balance performance was quantified using three outcome measures: the mean of BESS scores for three BESS series, the number of trials with steps/falls in three consecutive series and the mean of CoP parameters for three series. CoP parameters studied in this experiment included mean speed of displacement on a firm surface, mean MedioLateral (ML) amplitude and root-mean-square values for ML displacement. These have all been shown to be predictive for falls in elderly.[25] Other parameters obtained were mean AP, ML and total speed of displacement on both surfaces. Occurrence of a step in any trial completely excluded its force plate measurements from further analysis. Such an error would have caused an excessive discrepancy between testing conditions and involved the possibility that the subject made contact outside the force plate, rendering force plate measurements useless.

Data analysis

Correct performance of the prescribed breathing was not objectively monitored during the actual trials. Therefore comparisons were made on an intention to treat basis, meaning trials were included regardless of compliance with the prescribed breathing patterns. Data from the BESS scores of all twelve subjects was found fit for analysis. The statistical program used was SPSS 20. For every breathing pattern the mean of three series was calculated in Excel. These means were compared with a Repeated Measures Analysis Of Variance, once sufficient normality of the data was found. Normality was tested using the Shapiro-Wilk test and normality was refuted for any $P < 0.05$. The number of trials with steps/falls occurring in three series was analyzed in the same manner.

From the force plate data major parts were excluded from the analysis for two reasons: Firstly, as expected many of the trials could not be used because the subjects made a step. Secondly, some of the data was unexpectedly lost because files could not be retraced back to the corresponding trial, due to a number of unexplained file-naming errors. Due to the missing data, the remainder was no longer balanced with respect to intervention sequences, i.e. some of the intervention sequences occurred more frequently than others. In order to arrive at a complete set of measurements that is balanced for sequence and gender, the investigator chose to reduce the number of BESS stances and participants included in the CoP analysis. Remaining BESS stances were double leg stance on firm ground, tandem stance on firm ground and double leg stance on the foam pillow (data for these stances was mostly complete because they rarely caused steps or falls). Remaining participants were six; one from each of the intervention sequences. Taking into account the requirements (balance for sequence, balance for gender and completeness of the subjects' data) two possible sets of six subjects remained, from which one was randomly chosen by drawing a piece of paper from a bag. The raw force platform data (force arms and moments) was processed using Excel to calculate the final outcome measures. Statistical comparisons of the three breathing conditions was done separately for each CoP parameter. Given the small sample size for CoP parameters, the non-parametric Friedman test was used.

To determine the significance level a Bonferroni correction was applied, which involves dividing the original significance level by the number of dependent variables. The rationale for such a correction is that the chance of a type I error (data accidently showing a statistical difference where there is actually none) increases proportionally with the number of dependent variables. The non-adjusted significance level was set at 0.1. Dependent variables taken into account were 20 (the BESS score, number trials with steps/falls and six CoP parameters for three stances). Inserting these numbers in the calculation gave: 0.1 / 20 = 0.005. Thus the adjusted significance level was 0.005.

Ethical paragraph

The study protocol was approved by the Medical Ethical Committee of Maxima Medisch Centrum (see Appendix III). All subjects signed the informed consent form. Privacy was respected and video footage was exclusively accessible to the author for BESS scoring. None of the results obtained were mentioned in combination with names but instead ID numbers were used. The names were noted on a separate and confidential list along with the number, so that subjects could be informed about their results or watch the video footage, if so desired. For safety reasons, a spotter was always present by the subject's side to prevent falls. The breathing patterns used were harmless and in the instructions special attention was paid to avoid hyper- and hypo-ventilation. Furthermore, subjects were explicitly told that whenever they were about to fall, they were to open their eyes and regain balance. Finally, subjects were generally healthy, free from respiratory disorders and impairment of the lower limb and back, thereby minimizing the risks involved.

Results

Eventually twelve subjects were recruited, of whom six males and six females, with a mean age of 24.3 (SD = 2.9 years, range 21-30 years). Analysis of CoP values was eventually limited to six subjects of whom three males and three females, with a mean age of 23.4 (SD = 1.2 years, range 21-25 years). Statistical analysis yielded no significant differences between breathing patterns for BESS scores (P = 0.919), number of steps/falls (P = 0.974) and CoP parameters (Table 1). BESS scores for AB, NB and TB averaged 10.1 (SD = 4.9) , 9.9 (SD = 5.7) and 9.7 (SD = 5.6), respectively. The amount of trials with steps/falls in three consecutive series averaged 5.8 (SD = 2.7), 5.8 (SD = 2.8) and 5.9 (SD = 2.7) for AB, NB and TB respectively. Medians and interquartile ranges of CoP parameters are presented in Table 1.

Table 1: Statistical comparison of CoP parameters for different breathing patterns (n=6)

	CoP related outcome measure	Median (Interquartile Range) of three trials for each breathing pattern (cm or cm/sec) AB	NB	TB	p*
Double leg stance on firm ground	velocity	3.62 (2.94-4.56)	3.64 (3.20-4.56)	3.30 (2.94-4.56)	0.600
	ML velocity	1.92 (1.74-2.71)	2.07 (1.84-2.71)	1.77 (1.70-2.71)	0.956
	AP velocity	2.62 (1.99-3.13)	2.57 (2.27-3.13)	2.41 (1.96-3.13)	0.591
	ML amplitude	0.71 (0.65-0.78)	0.63 (0.58-0.78)	0.66 (0.58-0.78)	0.145
	AP amplitude	0.82 (0.64-0.89)	0.79 (0.68-0.89)	0.86 (0.75-0.89)	0.430
	RMS of ML displacement	0.024 (0.023-0.035)	0.027 (0.024-0.035)	0.023 (0.022-0.035)	0.740
Tandem stance on firm ground	velocity	7.95 (6.43-9.15)	7.15 (6.30-9.15)	7.69 (7.03-9.15)	0.684
	ML velocity	4.94 (3.99-5.81)	4.55 (4.01-5.81)	4.79 (4.35-5.81)	0.713
	AP velocity	4.99 (4.16-6.00)	4.73 (4.29-6.00)	4.83 (4.27-6.00)	0.752
	ML amplitude	0.72 (0.61-0.89)	0.71 (0.56-0.89)	0.84 (0.65-0.89)	0.690
	AP amplitude	1.10 (1.03-1.20)	1.12 (0.86-1.20)	1.12 (0.94-1.20)	0.622
	RMS of ML displacement	0.066 (0.054-0.080)	0.060 (0.053-0.080)	0.063 (0.058-0.080)	0.736
Double leg stance on foam pillow	velocity	7.85 (7.24-10.46)	7.42 (6.89-10.46)	7.19 (6.91-10.46)	0.956
	ML velocity	4.58 (4.43-5.76)	4.33 (3.92-5.76)	4.33 (3.92-5.76)	0.956
	AP velocity	5.40 (4.81-7.27)	5.11 (4.76-7.27)	5.11 (4.76-7.27)	0.740
	ML amplitude	1.32 (1.13-1.55)	1.23 (1.16-1.55)	1.21 (1.03-1.55)	0.852
	AP amplitude	1.35 (1.26-1.62)	1.25 (1.17-1.62)	1.25 (1.18-1.62)	0.570
	RMS of ML displacement	0.060 (0.057-0.075)	0.056 (0.052-0.075)	0.056 (0.052-0.075)	0.956

Abbreviations: Adominalbreathing (AB), Normal Breathing (NB), Thoracic Breathing (TB), MedioLateral (ML), AnteroPosterior (AP), Root-Mean-Square (RMS)
**Computed with the Friedman test, significance level is set at 0.005*

Discussion

This study aimed to determine whether AB improves balance performance in comparison to NB and TB in challenging balance conditions, to help determine whether AB should play a role in physiotherapeutic fall prevention for elderly people. The results suggest that neither AB, NB or TB have any significant effect on balance performance, as measured by BESS scores, number of steps/falls and the CoP parameters used in this study.

Interestingly, this is in contrast with the results of Hamaoui et al., who found more favorable CoP measures in AB than in TB. They measured AP and ML CoP amplitudes in ten healthy young adults (mean age 25, SD = 5) and manipulated three dependent variables: posture (sitting and standing), locus of breathing (AB and TB) and depth of breathing (deep, quiet and apnoea i.e. no breathing). Subjects stood on firm ground with the feet shoulder width apart and with open eyes. One of their findings was a significantly smaller mean AP CoP amplitude in AB than TB, in both sitting and standing. However, in standing this difference only reached significance with deep breathing ($P < 0.05$) whereas only a trend was found with quiet breathing.[22]

Their findings and the differences in methodology might explain why they did find a difference in favor of AB, while no difference emerged in this study.[22] Firstly, deep breathing used by Hamaoui et al. (opposed to normal depth of breathing in this study) might have increased the differences between breathing patterns, thereby attaining significance.[22] However, since in this study not even a trend was found in favor of AB, deep breathing is unlikely to account fully for the discrepancies between studies. Another plausible factor is that due to the greater difficulty of the stances in this experiment, compliance with the prescribed breathing patterns might have been poor. This might have prevented potentially existent effects from emerging.

Finally, there is another theory that might indirectly explain the contrasting results: Rather than counteracting other destabilizing influences, AB might only be less disturbing to balance than TB. In other words, it would ‘do less harm’ rather than providing active protection. Some evidence for this theory is also provided by Hamaoui et al.: They found that AP sway in both breathing conditions increased from apnoea to quiet breathing, and again from quiet breathing to deep breathing, which suggests that respiration does indeed disturb balance.[22] Their data also implies that AB is less of a disturbance, as it was accompanied by a smaller increase in sway than TB.[22] To understand how this theory can explain the contrasting results, one should imagine its implications when disturbances (other than breathing) and their resulting sway increase: Since AB would have no effect on these other disturbances, when they increase AB will become a relatively smaller factor. Probably due to the more difficult stances used, the mean AP amplitudes in this study (0.79 – 1.35 cm) were indeed greater than that of Hamaoui et al. (< 0.35 cm) [22] and this might have reduced AB to a proportionally minute and immeasurable factor. Shortly, differences in results could be a consequence of differences in depth of breathing, lack of compliance with prescribed breathing patterns and/or the possibility that AB is not protective but merely less disturbing than TB.

Unique to this study was the implementation of the BESS. The BESS takes into account other manifestations of imbalance than force plate posturography and therefore contributed to a broader perspective on the effects of locus of breathing. An isolated analysis was even made for steps and falls (excluding the other BESS errors), which increases the link to fall prevention in elderly people. Also, the number of CoP parameters included was quite extensive and included some that have previously been shown to be predictive for falls in elderly. Another strength was the inclusion of NB, which is a clinically more relevant control intervention than TB. Furthermore, in accordance with the intention to treat principle, this study assessed the effect of the used intervention (brief instructions and practicing) rather than the direct effect of locus of breathing. This benefits its generalizability to clinical practice, where treatment protocols do not always work out as intended either, especially in difficult multitasking conditions.

The methodology of this study has a number of weaknesses: Firstly, the sample size was small and limited the statistical power. Regarding generalizability to clinical practice, it must be said that a sensible physiotherapeutic treatment protocol would have been more extensive, involving a longer duration and a more gradual build up towards difficult multitasks with balancing. Limiting inclusion to healthy young participants also reduced the generalizability to the population of elderly fallers. Concerning compliance, some subjects confirmed that they failed to continuously perform the prescribed breathing because breathing and balance were both competing for their attention. Unfortunately, locus of breathing was not objectively checked during this experiment. With respect to BESS scoring, performance was filmed by only one camera and as a result some errors (obscured by the stance leg) may not have been observed. On the other hand, the BESS is normally scored by a single observer and its reliability has also been confirmed in this way. Thus the assumption was made that scoring based on a video recording was at least as accurate. Because of the practical circumstances, most measurements had to be made with a mobile force plate, which was higher than floor level. This is not consistent with the usual BESS protocol, in which the subject or foam pillow is on level ground. As a result, the reliability that was established for the BESS might not fully apply to its use in this experiment.

There were also unforeseen limitations to this study: As two subjects were about to be tested, the lab became temporarily unavailable due to faulty planning. Therefore four subjects, including two whom's force plate data was later included, had to be tested in a class room at the facility. Due to these circumstances, experiments of two subjects had to be interrupted for two hours between the first and second breathing patterns, i.e. between AB and NB for one subject and between AB and TB for the other. The latter subject's force plate data was also included in the analysis. Although otherwise consistency of intervals between trials was mostly maintained, experiments were sometimes unintentionally interrupted up to several minutes, mostly due to computer problems. As a result of these inconsistencies, possible differences in recovery time may have acted as a confounding factor. On one occasion technical problems occurring midway an experiment necessitated the use of another force plate (of the same model) that was level with the floor and thus notably different. This was potentially confounding since the need to habituate to this change might have negatively affected performance. As previously described only six out of twelve subjects were selected for CoP analysis, to maintain a balance for sequence effects (e.g. learning and fatigue) and carry-over effects. Consequently statistical power was lost. To yield more power, another option would have been to simply include all the available data. However, it was estimated that the resulting imbalance (for sequence effects especially) would be unacceptable.

Based on the results of this study, AB would be of no additional value in fall prevention treatment. No adverse effects were found either. The results showed that the short interventions used, did not provide protection from instability in challenging balancing situations. Although contrastingly, Hamaoui et al. indicated benefits of AB in non-challenging balance conditions[22], protection is rather needed in situations in which stability is being perturbed. In this respect the results of this study are more generalizable to clinical practice than those of Hamaoui et al. No research has yet been done on the effect of more extensive AB interventions. Conclusively, there is presently no scientific basis for the use of AB in fall prevention. Future studies could record respiratory changes in abdominal and thoracic circumference using inductance plethysmography, to objectively check compliance with the prescribed locus of breathing. Alternatively, these recordings could also be used to calculate the ratio between abdominal circumference and thoracic circumference, to indicate to what extent breathing is abdominal. This ratio would only be valid for within subject comparisons but it could still be used to check for within subject correlations between the ratio and balance performance. Furthermore this study has indicated that if any existent effect is to be found, the intervention has to be more extensive, including a longer duration and a gradual build up towards multitask conditions. To maximize generalizability to the elderly population, the participants should be selected accordingly.

Conclusion

In this study, AB, NB and TB demonstrated no significantly different effects on balance, as measured by BESS scores, number of trials with steps/falls and six CoP parameters. However, due to the methodological limitations, its result should be interpreted with caution. Nevertheless, it can be concluded that there is currently no scientific basis for the use of AB in fall prevention. Further research should be done, focusing on a more extensive AB intervention, of longer duration and with a more gradual build up. Also, studying elderly subjects and objectively measuring their compliance with the breathing patterns would be of additional value.

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Literature

1. Tromp AM, Smit JH, Deeg DJH. Predictors for Falls and Fractures in the Longitudinal Aging Study Amsterdam.J Bone Miner Res. 1998 Dec;13(12):1932-9.
2. Peel NM, Kassulke DJ, McClure RJ. Population based study of hospitalised fall related injuries in older people. Inj Prev. 2002 Dec;8(4):280-3.
3. Muir SW, Gopaul K, Montero Odasso MM. The role of cognitive impairment in fall risk among older adults: a systematic review and meta-analysis. Age Ageing. 2012 May;41(3):299-308.
4. Luukinen H, Koski K, Honkanen R, Kivelä SL. Incidence of injury-causing falls among older adults by place of residence: a population-based study. J Am Geriatr Soc. 1995 Aug;43(8):871-6.
5. Brennan J, Johansen A, Butler J, Stone M, Richmond P, Jones S, Lyons RA. Place of residence and risk of fracture in older people: a population-based study of over 65-year-olds in Cardiff. Osteoporos Int. 2003 Jul;14(6):515-9.
6. Saskatchewan Health. Fall Injuries Among Saskatchewan Seniors, 1992/93 to 1997/98: Implications for Prevention. Population Health Branch, Saskatchewan Health, Canada, ISBN 1-55157-015-7. 2002 Oct; 18-19.
7. Delbaere K, Van den Noortgate N, Bourgois J, Vanderstraeten G, Tine W, Cambier D. The Physical Performance Test as a predictor of frequent fallers: a prospective community based cohort study. Clin Rehabil. 2006 Jan;20(1):83-90.
8. Piirtola M, Pertti E. Force Platform Measurements as Predictors of Falls among Older People – A Review. Gerontology 2006;52:1–16.
9. Definition of centre of pressure in Oxford Dictionaries (British & World English) [Internet]. 2013 [updated 2013 May 9; cited 2013 May 9].
   Available from:
   http://oxforddictionaries.com/definition/english/centre%2Bof%2Bpressure___1 http://oxforddictionaries.com/definition/english/centre%2Bof%2Bpressure___1
10. Herdman SJ, Blatt P, Schubert MC, Tusa RJ. Falls in patients with vestibular deficits. Am J Otol. 2000 Nov;21(6):847-51.

11. Salonen L, Kivelä S. Eye Diseases and Impaired Vision as Possible Risk Factors for Recurrent Falls in the Aged: A Systematic Review. Curr Gerontol Geriatr Res. 2012;2012:271481.
12. Kojima T, Akishita M, Nakamura T, Nomura K, Ogawa S, Iijima K, et al. Polypharmacy as a risk for fall occurrence in geriatric outpatients. Geriatr Gerontol Int. 2011 Oct;11(4):438-44.
13. Rhalimi M, Helou R, Jaecker P. Medication use and increased risk of falls in hospitalized elderly patients: a retrospective, case-control study. Drugs Aging. 2009;26(10):847-52.
14. Shaffer SW, Harrison AL. Aging of the Somatosensory System: A Translational Perspective. Phys Ther. 2007 Feb;87(2):193-207.
15. Campbell AJ, Robertson MC, Gardner MM, Norton RN, Buchner DM. Psychotropic medication withdrawal and a home-based exercise program to prevent falls: a randomized, controlled trial. J Am Geriatr Soc. 1999 Jul;47(7):850-3.
16. Stel VS, Smit JH, Pluijm SMF. Consequences of falling in older men and women and risk factors for health service use and functional decline. Age Ageing. 2004 Jan;33(1):58-65.
17. Hartholt KA, van Beeck EF, Polinder S, van der Velde N, van Lieshout EMM, Panneman MJM, et al. Societal consequences of falls in the older population: injuries, healthcare costs and long term reduced quality of life. J Trauma. 2011 Sep;71(3):748-53.
18. Kimura BJ, Dalugdugan R, Gilcrease GW, Phan JN, Showalter BK, Wolfson T . The effect of breathing manner on inferior vena caval diameter. Eur J Echocardiogr. 2011 Feb;12(2):120-3.
19. Bussels B, Goethals L, Feron M, Bielen D, Dymarkowski S, Suetens P, et al. Respiration-induced movement of the upper abdominal organs: a pitfall for the three-dimensional conformal radiation treatment of pancreatic cancer. Radiother Oncol. 2003 Jul;68(1):69-74.
20. Hodges PW, Martin Eriksson AE, Shirley D, Gandevia SC. Intra-abdominal pressure increases stiffness of the lumbar spine. J Biomech. 2005 Sep;38(9):1873-80.
21. Hodges PW, Gandevia SC. Changes in intra-abdominal pressure during postural and respiratory activation of the human diaphragm. J Appl Physiol. 2000 Sep;89(3):967-76.
22. Hamaoui A, Gonneau E, Le Bozec S. Respiratory disturbance varies according to respiratory mode. Neurosci Lett. 2010 May 21;475(3):141-4.
23. Broglio SP, Zhu W, Sopiarz K, Park Y. Generalizability theory analysis of balance error scoring system reliability in healthy young adults. J Athl Train. 2009 Sep-Oct;44(5):497-502.
24. University of North Carolina's Sports Medicine Research Laboratory. Balance Error Scoring System (BESS) [Internet]. [updated: 2010 Apr 26; cited 2013 Jan 29].
Available from:
http://fs.ncaa.org/Docs/health_safety/BESS%20manual%20310.pdfhttp://310.pdf/
25. Piirtola M, Pertti E. Force Platform Measurements as Predictors of Falls among Older People – A Review. Gerontology 2006;52:1–16.

Appendices

Appendix I: Informed Consent Form

RESEARCH SUBJECT INFORMED CONSENT FORM

Prospective Research Subject: Read this consent form carefully and ask as many questions as you like before you decide whether you want to participate in this research study. You are free to ask questions at any time before, during, or after your participation in this research.

Project Information

Project Title: Breathing and balance	
Principal Investigator: Alexander Janzing	Organization: Fontys University of Applied Sciences
Location: Dominee Theodor Fliednerstraat 2, 5631 BN Eindhoven	Phone: 06 49 25 54 31

1. **PURPOSE OF THIS RESEARCH STUDY**
   You are hereby invited to participate in a research experiment, investigating the effect of abdominal and thoracic breathing on upright balance.
2. **PROCEDURES**
   For time efficiency you will be tested along with one other person. The location is the gait lab. After signing the informed consent, you will be familiarized with either thoracic, normal or abdominal breathing and get the chance to practice the breathing for five minutes. Then three Balance Error Scoring System (BESS) series will follow, during which you should try to maintain the breathing pattern. After a break the procedure will be repeated with the other breathing patterns.
   The BESS test covers a range from low to high balance demands. One series consists of six twenty second trials including three stances of varying difficulty on two surfaces (firm ground and foam pillow). You will be standing on the force plate or foam pillow overlying the force plate. Each time you will be asked to assume a stance, close your eyes and maintain the position for twenty seconds, with a spotter by your side in case you loose balance. Your performance will be filmed by two video-camera's, to be scored according to the BESS. Part of you performance will also be measured with the force plate, which can be used to calculate the amount of instability.
3. **POSSIBLE RISKS OR DISCOMFORT**
   All together the experiment will take between 1h 45 min. and 2 h of your time, including sufficient breaks. There will be a small risk of falling. This risk is limited because you are allowed to open your eyes and regain your balance once you loose it and because a spotter will be present besides you. If you follow instructions on the breathing patterns they will involve no danger.
4. **POSSIBLE BENEFITS**
   By participating you would contribute to results that may help determine if and how breathing may improve balance. Improving balance can help to prevent falls in elderly people, along with the injury, loss of function and death that they cause.
   Additionally, through experience as a subject you will be thoroughly familiarized with a balance test and you will observe first hand how an experiment is conducted.

5. **FINANCIAL CONSIDERATIONS**

   There is no financial compensation for your participation in this research.

6. **CONFIDENTIALITY**

   Your privacy will be protected. Results and camera footage obtained from the experiment will be treated as confidential. Results (not video footage) may be published for scientific purposes but will not give your name or any other identifiable references to you. Video footage will only be inspected by Alexander Janzing, who is also conducting the research. It will serve only for BESS evaluation and will be destroyed upon completion of the study.

   If you wish to obtain any of your results or recordings made this will be arranged. Your name will then be listed separately and confidentially with a reference to your data. This list will also be destroyed upon completion of the study.

7. **TERMINATION OF RESEARCH STUDY**

   If you wish to withdraw from the study you are absolutely free to do so at any time without consequences.

8. **AVAILABLE SOURCES OF INFORMATION**

   Any further questions you have about this study will be answered by the Principal Investigator, whom you may also contact about any problems related to this study:

   Name: Alexander Janzing

   Telephone number: 0649255431

   E-mail: ajanzing@student.fontys.nl

9. **AUTHORIZATION**

   I have read and understand this consent form, and I volunteer to participate in this research study. I understand that I will receive a copy of this form. I voluntarily choose to participate, but I understand that my consent does not take away any legal rights in the case of negligence or other legal fault of anyone who is involved in this study. I further understand that nothing in this consent form is intended to replace any applicable Federal, state, or local laws.

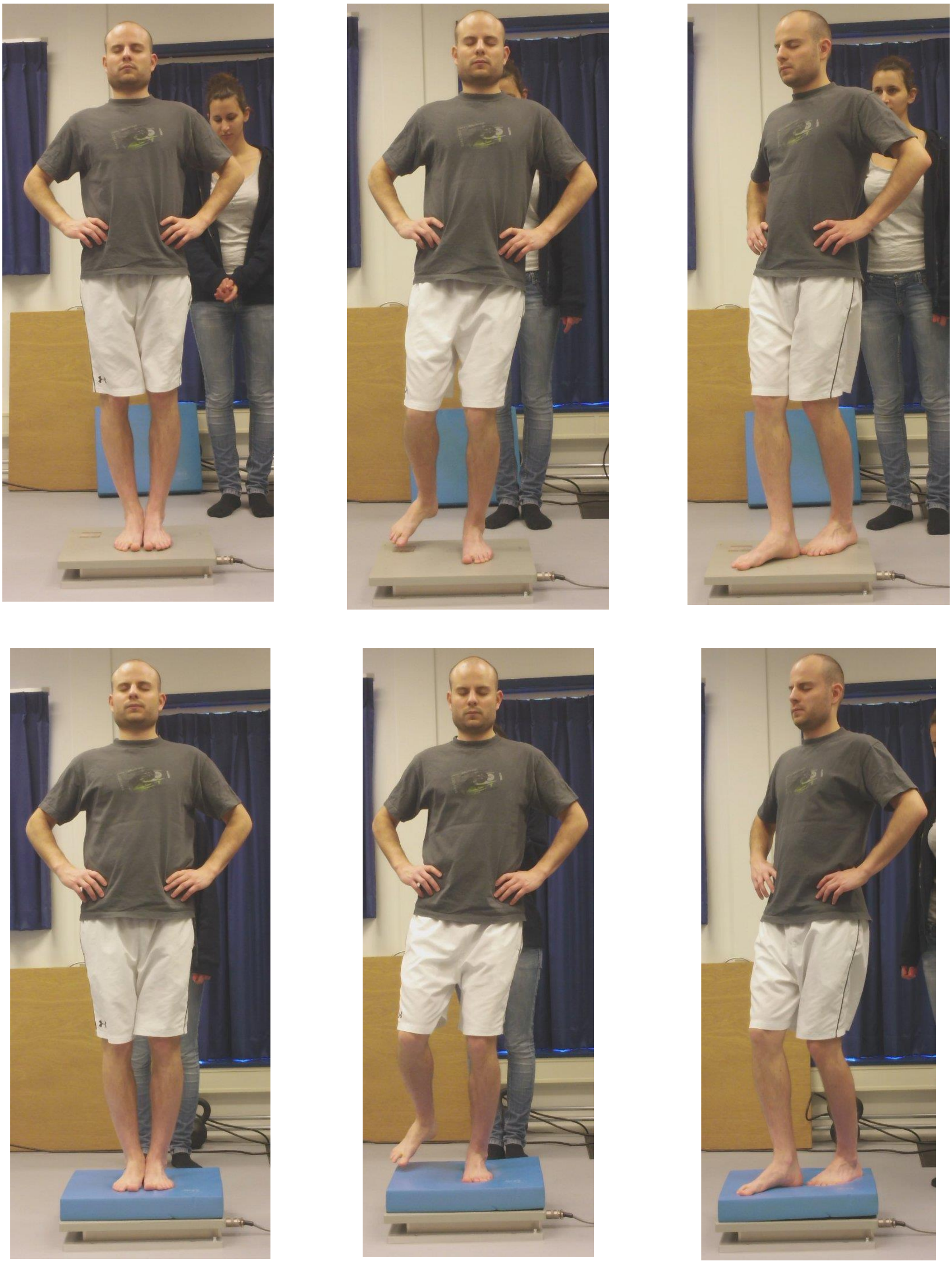
   Participant Name:
   Date:

   Participant Signature:
   Date:

   Principal Investigator Signature:
   Date:

   Signature of Person Obtaining Consent:
   Date:

Appendix II: BESS stances



From left to right: double leg stance, single leg stance and tandem stance.
Top row: Firm ground
Bottom row: foam pillow

Appendix III: Approval by Medical Ethical Commitee

máxima
medisch centrum

medisch ethische toetsingscommissie
secretariaat
telefoonnummer: 040888 9528
e-mail:metc@mmc.nl

Dhr. A. Janzing
Fontys Hogeschool
Eindhoven

Datum:	24-01-2013
Betreft:	WMO-plichtigheid
Studie:	*Balance and breathing*

Geachte heer Janzing,

De medische ethische toetsingscommissie (METC) van Máxima Medisch Centrum heeft bovengenoemd onderzoeksvoorstel ontvangen op 23 januari 2013. Het dagelijks bestuur van de commissie is tot de conclusie gekomen dat het onderzoek niet onder de werkingssfeer van de *Wet medisch wetenschappelijk onderzoek met mensen* (WMO) valt. De METC acht deze studie, waarin twee ademhalingstechnieken en de invloed daarvan op het houden van balans worden vergeleken, niet toetsingsplichtig aangezien er geen sprake is van het 'onderwerpen van personen aan handelingen of het opleggen aan personen van een bepaalde gedragswijze' in de zin van de wet. Er wordt niet gerandomiseerd, er vindt geen interventie plaats en de studie levert geen belasting en/of risico op voor de deelnemers. De METC acht bovengenoemde studie om die redenen niet toetsingsplichtig.

Ik hoop u hiermee voldoende geïnformeerd te hebben.

Met vriendelijke groet,

Mw. mr. C.M. Swolfs
Ambtelijk secretaris METC

Appendix IV: Assessment form project plan

B4 Assessment form project plan

Name: Alexander Janzing Student no: 2146422

Date: 18-2-2013

Title: Balance and breathing

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 not very relevant

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 proposal was already assessed by the local ethics committee, and approved! The physiotherapeutic relevance can be introduced a bit stronger, although a connection with a relevant predictor (i.e. sway) is made. High quality English! Remember the rules of the gait lab: no eating and drinking allowed, so eat and drink the tea and cookie somewhere else.
A clinically relevant reference condition (normal breathing) was introduced.
The instruction for normal breathing ("do NOT THINK ABOUT" leads automatically to thinking about it) is difficult in practice......
The global planning is presented is good level of detail!
Peer review is presented only once, which is a bit limited...
Reference list not fully consistent.

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: Jaap Jansen

Date + Signature 18-2-2013

Chris Burtin

Appendix V: Confidentiality statement

Fontys Paramedische Hogeschool

B8. Confidentiality statement

Name: Alexander Janzing Student No°: 2146422

Title: The effect of locus of breathing on balance

Content (description): This study investigates a potentially new tool for physiotherapeutic fall prevention in elderly, namely abdominal breathing. It compares the effects of abdominal breathing, normal breathing and thoracic breathing on balance, as measured by the Balance Error Scoring System (BESS), number of trials with steps/falls for three BESS series and CoP parameters.

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: Alexander Janzing

(signature) Date: 30/05/2013

Supervisor:

Name: [illegible]

(signature) Date: __/__/____ 30-5-2013

Coordinator: for receipt

Name: ____________

(signature) Date: __/__/____

Appendix VI: Conveyance of Rights Agreement

Fontys Paramedische Hogeschool

B9. 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. Mr/Ms Alexander Gerard Johannes Janzing
[*full name as stated in passport*], residing at 5653 EW, Eindhoven
[*postal code, place of residence*] at the Chopinlaan 6
[*street and house number*], 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.

X

Fontys Paramedische Hogeschool

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:

Name: Alexander Jonzing

(signature)

Date: 30/05/2013

Place: Eindhoven

Fontys Institute
trading under the name Fontys Hogescholen
Supervisor:

Name: Jaap Janse

30. 5-2013 (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]