'This is the peer reviewed version of the following article: Jennifer B. Hodkinson , Susan J. Gordon , Robert G. Crowther & Petra G. Buettner (2013) Time to stabilisation of the cervical spine when supported by a pillow in side lying, Ergonomics, 56:9, 1474-1485, DOI:10.1080/00140139.2013.819938

which has been published in final form at
http://dx.doi.org/10.1080/00140139.2013.819938

"This is an Accepted Manuscript of an article published by Taylor & Francis in Ergonomics on 22 July 2013, available online: http://
www.tandfonline.com/10.1080/00140139.2013.819938."

Time to stabilisation of the cervical spine when supported by a pillow in side lying

Ergonomics

Corresponding author:

Jennifer B. Hodkinson B Physio (Hons)

Discipline of Physiotherapy, James Cook University, Townsville, Australia

Correspondence address – Angus Smith Drive, Townsville, Queensland 4811

jennifer.hodkinson@my.jcu.edu.au

Co-authors:

Susan J. Gordon PhD

Discipline of Physiotherapy, James Cook University, Townsville, Australia

Correspondence address – Angus Smith Drive, Townsville, Queensland 4811

susan.gordon2@jcu.edu.au

Robert G. Crowther PhD

Institute of Sport and Exercise Science, James Cook University, Townsville, Australia

Correspondence address – Angus Smith Drive, Townsville, Queensland 4811

robert.crowther@jcu.edu.au

Petra G. Buettner PhD

Anton Breinl Centre, James Cook University, Townsville, Australia

Correspondence address – Angus Smith Drive, Townsville, Queensland 4811

petra.buttner@jcu.edu.au

Acknowledgements:

The Discipline of Physiotherapy and the Institute of Sport and Exercise Science, James Cook University, Australia, provided in kind support for this project.

Abstract

Currently there is no information to guide consumers, retailers and health professionals about the length of time it takes for the cervical spine to stabilise when resting on a pillow. The aim of this study was to determine the time required to achieve stabilisation of the cervical spine when supported by a polyester pillow and innerspring mattress in side lying. Twenty-four asymptomatic females rested in a standardised side lying position during the capture of three dimensional data from markers placed over cervical landmarks. Time to stabilisation was assessed for each axis, each landmark, and globally for each participant. A large variation in global stabilisation times was identified between participants, however, 70.8% of participants had stabilised by 15 mins or earlier. Fifteen mins is the best estimate of the time to stabilisation of the cervical spine for young females in a side lying position when resting on a polyester pillow.

Keywords

motion analysis; cervical spine; stabilisation; three dimensional; VICON Nexus; pillow

Practitioner Summary

This study aimed to determine the time required to achieve stabilisation of the cervical spine when supported by a polyester pillow and innerspring mattress in side lying. Through a laboratory study using 3D VICON motion analysis technology we identified that 70.8% of participants had stabilised by 15 minutes.

1.0.Introduction

When a person rests their head on a pillow gravitational forces cause compression of the pillow content and creep of the soft tissues and viscoelastic spinal ligaments until equilibrium is reached (Gracovetsky, 1987). Currently there is no information to guide consumers, retailers or health professionals about the length of time it takes for the cervical spine to stabilise when resting on a pillow. However there is evidence that resting for 10 mins on different pillow types results in a variation in cervical spine posture (Gordon, Grimmer-Somers, Trott, 2011) and that changing pillow type can alter sleep quality and waking cervical complaints such as cervical pain and stiffness, headaches and scapular pain (Erfanian et al., 2004, Gordon et al., 2009, Hagino et al., 1998, Lavin et al., 1997, Persson and Moritz, 1998, Persson, 2006). Establishing the amount of time for cervical spine stabilisation would provide information on which to base pillow selection.

It has recently been established that three dimensional motion analysis using VICON technology is reliable and effective for investigating the behaviour of the cervical spine when resting on a pillow in side lying (Hodkinson et al., under review). Exploration of methods to analyse VICON data using a small sample determined that calculating slope (or general change in position over time) for five minute blocks of data provided the best estimate of stabilisation of the cervical spine (Hodkinson et al., under review).

Cervical range of motion decreases with age (Hole et al., 1995, Lansade et al., 2009, Salo et al., 2009, Trott et al., 1996) and women typically have a greater range of cervical motion than men (Ferrario et al., 2002, McClure et al., 1998, Nilsson et al., 1996). Therefore, research which analyses movement of the cervical spine should control for these variables. Also, since polyester pillows are the most commonly used pillow type (Gordon et al., 2009) and since approximately 72% of adults spend most of their sleep time in the side lying position (Gordon et al., 2007), studies which assess the side lying position on a polyester pillow would relate to the majority of the Australian population.

This study used VICON three dimensional analysis to determine the amount of time required for stabilisation of the cervical spine when side lying on a polyester pillow and innerspring mattress in side lying.

2.0. Methods

The method of this study replicates the method used in a previous pilot study, however a brief version is provided here for convenience of the reader (Hodkinson et al., under review).

2.1. Participants

Female participants aged 18 to 27 years were recruited via an email sent to all James Cook University (JCU), Australia, rehabilitation science students and snowballing. Participants were included if they had no neck or thoracic pain lasting longer than 24 hours in the last six months, no fractures to the spine, no history of neck surgery and were not diagnosed with a chronic spinal condition and were excluded if they were pregnant. All participants were provided with an information sheet and signed an informed consent form, approved by the JCU Human Research Ethics Committee, prior to data collection.

2.2. Measurement of height and weight

Height and weight were measured to provide descriptors of participants. Each participant was asked to stand in bare feet with their back to a stadiometer for their height to be measured. They were asked to look straight ahead, have their heels touching the base of the vertical board, and stand with their weight evenly distributed on both feet. The movable head board was brought to the most superior point of their head and the measurement was recorded to the nearest 0.1cm (Lohman et al., 1991). The participant then stood in bare feet on digital scales, for their weight to be measured to the nearest 0.1kg (Lohman et al., 1991).

2.3. Data capture using VICON technology

VICON Nexus Version 1.5.2. was used for this study with hardware consisting of four VICON MX3 cameras, two MX Links, one MX Control and one MX Net (VICON Centennial, CO, USA). The participant was guided into a standardised position on a Nest Pillow-top Single Ensemble (Select-O-Pedic Bedding, Moorabbin, Australia) in right side lying with their head resting on the polyester pillow (Tontine Easy Care, Campbellfield, Australia). An elastic headband was placed over the external occipital protuberance (EOP), and handmade reflective spherical markers (7 mm in diameter) were placed over the EOP and spinous processes of the second, fourth and seventh cervical vertebrae (C2, C4, C7) and third thoracic vertebrae (T3). Four VICON cameras were positioned posterior to the participant so that each camera was able to gather data from all five markers. Participants were asked to place their head so that their ear was just touching the surface of the pillow. They were then asked to rest their head onto the pillow at the word "Go" when simultaneously the VICON capture was started. Participants rested in the standardised position, remaining as still as possible, for 20 mins, while the marker position was recorded in three axes x, y, and z, every 0.02 s (50Hz). Movement recorded in the x axis represented any forward or backward movement of the marker. This could come from rotation, protraction or retraction and flexion or extension. The y axis recorded movement of the marker cranially or caudally. The z axis detected any rise or fall of the marker which was considered to represent mainly lateral flexion, however, rotation would also be detected as movement of the marker in this axis.

2.4. Data management

Usable data was collected from 24 eligible participants. A macro program in Microsoft Excel was used to extract VICON data for every 10 s of data point. The data for the first 10 s was not included in the analysis in order to exclude the act of resting the head onto the pillow, as the purpose of this study was to track cervical motion once the participant's head was rested on the pillow.

2.5. Data analysis

All data was transferred into Statistical Package for the Social Sciences Statistics 19 (IBM, New York, USA) in five minute blocks, such that variable EOPX1 contained the positions for a participant's EOP marker in the x axis from 10 s to five mins, EOPX2 from five to 10 mins, EOPX3 from 10 to 15 mins and EOPX4 from 15 to 20 mins and so forth for each marker in each axis. A linear regression was calculated for each variable to determine the slope (or general change in position over time) for the five mins. A slope between -0.5 and 0.5 was considered stable, based on the method of the pilot study (Hodkinson et al., under review). A negative slope in the x axis represented posterior movement of a marker in the x axis, movement cranially in the y axis and lateral flexion down onto the pillow in the z axis. From these slopes, stabilisation for each participant was assessed in three ways: 1) the time that stabilisation had occurred for all landmarks in a single axis, 2) the time that stabilisation had occurred for all axes at a single landmark, and 3) the time all landmarks had stabilised in all axes.

3.0. Results

3.1. Participants

The mean age of the 24 participants was 20 years (range 18 to 24 years). Participants mean height was 165.6cm , ranging between 158.0cm and 183.3cm. Weight ranged between 43.6kg and 93.6kg, with a mean weight of 62.6kg and the average body mass index was 22.8kg/m^2.

3.2. Stabilisation times

The slope used to calculate stabilisation times for each landmark (n=5) and each axis of motion (n=3) for all participants (n=24) are provided as Appendix A.

3.2.1. Time to stabilisation for all landmarks in a single axis

The greatest variability in time to stabilisation for all landmarks occurred in the x axis. In fact, approximately one fifth of participants were not stable by 20 mins in this axis. All landmarks in the y axis were stable from the beginning and throughout the 20 mins in 91.7% of participants. All landmarks of almost half of the participants (45.8%) were stable in the z axis from the beginning of data capture, and by 15 mins 83.3% of participants had all landmarks stable in the z axis (Table 1).

Table 1: Time to stabilisation for all landmarks in each individual axis (n=24 participants)

	Time (mins)	**No. (%) of participants with all landmarks stable**	**Cumulative % of participants with all landmarks stable**
x axis	0	7 (29.2)	29.2
	5	4 (16.7)	45.9
	10	3 (12.5)	58.4
	15	5 (20.8)	79.2
	Did not	5 (20.8)	-
y axis	0	22 (91.7)	91.7
	5	1 (4.2)	95.9
	10	0	95.9
	15	1 (4.2)	100.0
	Did not	0	-
z axis	0	11 (45.8)	45.8
	5	2 (8.3)	54.1
	10	3 (12.5)	66.6
	15	4 (16.7)	83.3
	Did not	4 (16.7)	-

3.2.2. Time to stabilisation for all axes at a single landmark

The EOP and C4 landmarks were stable in all axes from the beginning of data capture in half of the participants. The C2, C7 and T3 landmarks also had a high percentage of participants achieve stabilisation in all axes from the beginning of data capture. In those participants where landmarks were not stable from the beginning, there was a trend that the more cephalic landmarks stabilised earlier, while the more caudal landmarks stabilised later (Table 2).

Table 2: Time to stabilisation for all axes in each individual landmark (n=24 participants)

	Time (mins)	No. (%) of participants with all axes stable	Cumulative % of participants with all axes stable
EOP	0	12 (50.0)	50.0
	5	6 (25.0)	75.0
	10	2 (8.3)	83.3
	15	2 (8.3)	91.6
	Did not	2 (8.3)	-
C2	0	10 (41.7)	41.7
	5	5 (20.8)	62.5
	10	2 (8.3)	70.8
	15	5 (20.8)	91.6
	Did not	2 (8.3)	-
C4	0	12 (50.0)	50.0
	5	1 (4.2)	54.2
	10	3 (12.5)	66.7
	15	4 (16.7)	83.4
	Did not	4 (16.7)	-
C7	0	11 (45.8)	45.8
	5	1 (4.2)	50.0
	10	2 (8.3)	58.3
	15	6 (25.0)	83.3
	Did not	4 (16.7)	-
T3	0	9 (37.5)	37.5
	5	1 (4.2)	41.7
	10	5 (20.8)	62.5
	15	5 (20.8)	83.3
	Did not	4 (16.7)	-

3.2.3. Time to global stabilisation in all landmarks and all axes.

A large variation was identified between participants when determining global stabilisation of all landmarks in all axes. It was found that 70.8% of participants had stabilised by 15 mins or earlier, and the remaining (29.2%) failed to stabilise in the 20 mins of data collection (Table 3).

Table 3: Time to global stabilisation in all markers and all axes (n=24 participants)

Time (mins)	**No. (%) of participants globally stable**	**Cumulative % of participants globally stable**
0	6 (25.0)	25.0
5	3 (12.5)	37.5
10	3 (12.5)	50.0
15	5 (20.8)	70.8
Did not	7 (29.2)	-

4.0.Discussion

This study identified a large variation in time to global stabilisation of the cervical spine in a young female population. Approximately 30% of participants did not stabilise in 20 mins which may indicate that for some people stabilisation never occurs. Conversely a quarter of participants were stable after 10 s of rest. Overall however, this research has established that the cervical spine of the majority of young females (70.8%) stabilised within 15 mins of side lying on a polyester pillow.

The variation in global stabilisation times shows that stabilisation could occur at any time and could even occur as early as once the head was rested onto the pillow, as a quarter of participants were stable from the start (Table 3). This raises the question as to whether those participants who had movement after the initial process of resting the head down onto the pillow (remembering the first 10 s was excluded from this study) were still in the process of settling into the pillow. It is possible that settlement into the pillow, involving compression of pillow and mattress content occurred in the first ten s (the time that was excluded from this study). The remaining movement after this could be related to general movement on the pillow, as the participant found a comfortable position. The variation in stabilisation times identified in this study could therefore reflect the time that participants took to find a comfortable position, within the limits of the standardised position that was assigned to them. No information was collected about participant comfort during data collection and this should be included in future studies.

When analysing stabilisation of landmarks in a single axis, all markers in the y axis were stable in most participants (91.7%) from the beginning of data capture. This is not unexpected as little movement is likely to occur cranially or caudally once participants had adopted the standardised position. In contrast, the anatomical markers in the x axis stabilised less quickly due to continuing rotation of the spine and lateral flexion in z axis. As the VICON technology detects the conjoint movement occurring in the spine it will detect rotation movement as a rise or fall of a marker in both the x and z axes (Hodkinson et al., under review). Therefore, it is highly likely that the participants may have finished depressing into the pillow, but they continue to rotate, and this is detected in the x and z axes. It is only when they stop rotating that they are considered to be completely stabilised. It is possible that this rotation is due to the trunk rotating on the head and neck as the upper shoulder moves anterior or posterior in relation to the shoulder rested on the bed. An underlying sinusoidal pattern of movement has been suggested to occur due to respiration and may contribute to this continued motion (Hodkinson et al., under review).The more caudal landmarks, T3 and C7, took longer to stabilise and this supports the hypothesis that the movement was trunk on neck rather than neck on trunk rotation. Further, all movement from zero (excluding 10 s of the participant resting the head onto the pillow) through to 20 mins could simply be movement on the pillow, unrelated to settlement into the pillow.

A study which analysed the slope of cervical segments at zero and 10 mins when lying in a standardised side lying position found that the slopes of cervico-thoracic spinal segments changed less than 0.01 units over the 10 mins (Gordon et al., 2011) This further supports our findings, that when eliminating all other movement, posture of the cervical spine after 10 mins is hardly different from the posture adopted once initial resting of the head onto the pillow has occurred.

Future studies which implement the standardised position used in this study should control the position of the upper shoulder throughout data capture to eliminate trunk rotation. However, standardising the resting position to this extent further limits the generalisability to real life of this type of research. This study was performed when participants were awake. The mechanics of the cervical spine may differ during sleep as the muscles are more relaxed, generating less active forces on the spine (Gracovetsky, 1987). Simply recruiting a group of side sleepers and asking them to lay on a bed, in their usual sleep position, as the movement of their spine was being tracked, would provide real life information.

People aged 18 to 24 years change sleep position around 3.6 times per hour while older adults change position less often (De Koninck et al., 1992). The data collected in this study is likely to represent the side lying posture a young female would adopt. Future studies should investigate time to stabilisation in older adults and males.

The results can not be generalised to those with a height and weight outside of participants' included in this study as it is possible that weight may influence the compression rate of a mattress and pillow. Future studies should investigate the effect of anthropometry on stabilisation time and alignment of the cervical spine when resting on an innerspring mattress and pillow, as this would assist health professionals in providing advice regarding pillow selection with respect to individual anthropometry. The results from this study can also only be related to a polyester pillow. Future studies should also investigate stabilisation of the cervical spine on pillows of different content and shape.

5.0. Conclusions

Approximately 70% of young females achieve stabilisation of the cervical spine within 15 mins of resting in a side lying position on a polyester pillow. This time can be used as a guide when assessing cervical spine posture and comfort on a polyester pillow.

Appendix A: Slopes for each of the 24 participants

Table A-1: Slopes for each five minute block in each participant (n=24) in the x axis used to calculate stabilisation times.

Underlined values are those considered not stable (i.e. <-0.5 or >0.5).

	EOP	C2	C4	C7	T3
P1 x					
0-5	-0.232	-0.440	-0.183	-0.049	0.368
5-10	-0.095	-0.100	-0.306	-0.016	-0.014
10-15	-0.103	-0.298	-0.351	-0.356	-0.385
15-20	-0.211	-0.273	-0.141	-0.293	-0.411
P2 x					
0-5	0.034	-0.140	-0.273	-0.428	-0.548
5-10	0.059	-0.156	-0.329	-0.273	-0.232
10-15	-0.034	-0.171	-0.177	-0.126	-0.296
15-20	-0.091	-0.173	-0.324	-0.366	-0.355
P3x					
0-5	0.025	0.055	0.093	0.118	0.048
5-10	0.616	0.178	0.377	0.474	0.402
10-15	0.495	0.527	0.628	0.543	0.648
15-20	-0.111	-0.097	-0.219	-0.251	-0.211
P4 x					
0-5	-0.330	0.300	0.302	0.426	0.423
5-10	0.240	0.027	-0.010	-0.212	-0.139
10-15	0.393	-0.098	-0.055	-0.021	-0.114
15-20	0.114	0.084	0.038	0.008	0.029
P5 x					
0-5	-0.082	0.074	0.567	0.674	0.744
5-10	0.455	0.591	0.680	0.382	0.531
10-15	0.177	0.026	-0.115	0.025	-0.082
15-20	0.459	0.347	0.349	0.381	0.407
P6 x					
0-5	0.149	0.077	0.146	0.121	0.323
5-10	0.068	0.168	0.243	0.168	0.028
10-15	0.320	0.077	0.105	-0.039	-0.098
15-20	0.027	0.071	0.059	0.102	0.056
P7 x					
0-5	-0.161	-0.262	-0.456	-0.469	-0.309
5-10	-0.447	-0.121	0.084	0.179	0.262
10-15	-0.463	-0.482	-0.545	0.147	0.205
15-20	-0.010	-0.260	-0.047	0.023	0.132
P8 x					
0-5	0.156	0.131	0.176	0.270	0.313
5-10	0.327	0.129	0.114	0.010	-0.009
10-15	0.264	0.223	0.173	0.126	0.075
15-20	-0.020	-0.107	-0.179	-0.191	-0.265
P9 x					
0-5	-0.690	-0.586	-0.611	-0.270	-0.054
5-10	-0.618	-0.705	-0.653	-0.823	-0.888
10-15	-0.479	-0.475	-0.571	-0.339	-0.456

15-20	0.522	0.665	0.724	0.549	0.261
P10 x					
0-5	-0.310	-0.130	0.044	0.048	-0.061
5-10	0.012	0.090	0.232	0.324	0.350
10-15	0.067	-0.057	-0.264	-0.508	-0.829
15-20	-0.101	-0.196	-0.520	-0.483	-0.431
P11 x					
0-5	-0.077	-0.295	-0.432	-0.353	-0.583
5-10	-0.374	-0.748	-0.675	-0.646	-0.796
10-15	-0.308	-0.537	-0.637	-0.598	-0.786
15-20	0.124	-0.146	-0.194	-0.307	-0.466
P12 x					
0-5	0.229	0.409	0.439	0.391	0.356
5-10	0.158	0.170	0.291	0.141	0.018
10-15	-0.216	0.176	0.186	0.289	0.219
15-20	0.063	-0.192	-0.224	-0.154	-0.142
P13 x					
0-5	-1.049	-1.291	-1.782	-1.783	-1.824
5-10	-0.703	-0.707	-0.755	-0.654	-0.551
10-15	-0.336	-0.545	-0.811	-0.612	-0.904
15-20	-0.264	-0.563	-0.706	-0.722	-0.877
P14 x					
0-5	-0.930	-0.850	-0.463	-0.189	0.009
5-10	-0.060	-0.030	-0.013	0.059	0.174
10-15	-0.120	-0.013	-0.047	0.013	0.041
15-20	-0.275	-0.252	-0.213	-0.086	0.030
P15 x					
0-5	0.256	0.339	0.357	0.258	0.183
5-10	0.290	0.251	0.034	0.046	-0.019
10-15	0.319	0.299	-0.040	0.076	-0.100
15-20	0.192	0.075	0.072	0.105	0.013
P16 x					
0-5	0.188	0.348	0.548	0.458	0.508
5-10	0.646	0.716	0.637	0.884	0.941
10-15	0.464	0.533	0.470	0.467	0.297
15-20	0.541	0.462	0.350	0.268	0.169
P17 x					
0-5	-0.234	-0.212	-0.050	-0.124	0.067
5-10	0.354	0.232	-0.076	-0.234	0.038
10-15	0.384	0.135	-0.171	-0.742	-0.651
15-20	-0.081	-0.074	-0.112	-0.321	-0.130
P18 x					
0-5	-1.159	-0.843	-1.022	-0.583	-0.537
5-10	-0.251	-0.551	-0.578	-0.821	-0.780
10-15	-0.059	-0.211	-0.363	-0.369	-0.386
15-20	-0.126	-0.203	-0.273	-0.444	-0.348
P19 x					
0-5	-0.078	0.133	0.169	0.245	0.813
5-10	0.165	0.011	0.107	0.232	0.933
10-15	-0.063	0.030	-0.093	0.147	0.479
15-20	0.013	0.073	0.180	0.276	0.165

P20 x					
0-5	-0.230	-0.573	-0.405	-0.387	-0.325
5-10	-0.406	-0.197	-0.355	-0.401	-0.301
10-15	0.008	-0.087	-0.003	-0.036	0.189
15-20	0.129	0.076	0.190	0.202	0.127
P21 x					
0-5	-0.769	-0.649	-0.484	-0.211	0.045
5-10	-0.101	-0.139	-0.124	-0.110	-0.202
10-15	0.100	0.052	-0.249	-0.309	-0.550
15-20	0.364	0.143	-0.659	-1.553	-1.840
P22 x					
0-5	0.060	0.086	0.211	0.179	0.171
5-10	0.284	0.114	0.037	-0.153	-0.185
10-15	0.164	0.148	0.040	0.208	0.248
15-20	-0.218	-0.187	0.090	0.224	0.068
P23 x					
0-5	-0.121	0.204	0.390	0.442	0.307
5-10	0.208	0.467	0.466	0.533	0.469
10-15	0.589	0.696	0.679	0.836	0.821
15-20	0.002	0.070	0.070	0.230	0.295
P24 x					
0-5	1.351	1.120	0.994	0.657	0.507
5-10	0.344	0.487	0.376	0.094	-0.196
10-15	-0.127	-0.236	-0.093	-0.219	-0.327
15-20	-0.410	-0.397	-0.464	-0.201	-0.201

Table A-2: Slopes for each five minute block in each participant (n=24) in the y axis used to calculate stabilisation times.

Underlined values are those considered not stable (i.e. <-0.5 or >0.5).

	EOP	C2	C4	C7	T3
P1 y					
0-5	-0.230	-0.043	0.001	0.207	0.111
5-10	0.012	0.013	0.057	0.027	0.000
10-15	0.036	0.015	-0.018	-0.021	-0.054
15-20	0.035	0.024	-0.028	-0.090	-0.090
P2 y					
0-5	0.023	-0.006	0.029	0.136	0.099
5-10	-0.020	0.007	0.015	0.014	0.098
10-15	-0.024	-0.092	-0.068	-0.043	-0.077
15-20	0.051	0.021	-0.068	-0.050	0.031
P3y					
0-5	-0.043	0.016	-0.020	-0.032	-0.087
5-10	0.099	0.110	0.076	0.043	0.017
10-15	0.089	0.111	0.192	0.073	0.054
15-20	-0.064	-0.061	-0.052	-0.035	-0.036
P4 y					
0-5	0.224	0.055	0.124	0.123	0.011
5-10	-0.042	-0.004	0.005	-0.033	0.039
10-15	-0.188	-0.021	-0.039	-0.019	-0.036
15-20	-0.005	0.002	0.005	-0.006	0.000

P5 y					
0-5	0.148	0.039	0.241	0.291	0.260
5-10	0.015	-0.034	0.054	0.094	0.254
10-15	0.003	-0.005	-0.111	-0.148	-0.128
15-20	0.204	0.117	0.036	-0.053	-0.159
P6 y					
0-5	0.045	-0.012	0.091	0.154	0.194
5-10	0.169	0.082	0.065	-0.047	-0.062
10-15	0.029	0.040	0.046	-0.030	-0.026
15-20	0.040	0.008	0.019	-0.048	-0.029
P7 y					
0-5	-0.057	-0.049	-0.125	-0.180	-0.042
5-10	0.129	0.114	0.145	0.172	0.178
10-15	-0.113	-0.089	-0.077	0.003	0.045
15-20	0.053	0.128	0.025	-0.045	-0.160
P8 y					
0-5	0.127	0.065	-0.032	-0.094	-0.133
5-10	0.154	0.167	0.001	-0.020	-0.039
10-15	0.129	0.098	0.051	-0.043	-0.094
15-20	0.019	0.001	-0.039	0.067	0.229
P9 y					
0-5	-0.148	-0.109	-0.121	0.005	0.002
5-10	0.007	-0.005	-0.019	-0.086	-0.007
10-15	-0.052	-0.056	-0.077	-0.073	-0.013
15-20	0.465	0.398	0.231	0.177	0.126
P10 y					
0-5	0.280	0.196	0.077	-0.252	-0.302
5-10	0.377	0.276	0.118	-0.032	-0.220
10-15	0.016	0.033	-0.072	-0.192	-0.127
15-20	-0.072	-0.047	-0.220	-0.124	-0.130
P11 y					
0-5	0.022	-0.017	-0.042	0.014	0.013
5-10	-0.055	-0.081	-0.169	-0.072	0.035
10-15	-0.061	-0.193	-0.242	-0.212	-0.123
15-20	0.078	0.089	-0.019	-0.070	-0.006
P12 y					
0-5	0.185	0.103	0.135	0.201	0.197
5-10	0.116	0.086	0.050	0.024	-0.004
10-15	0.232	0.058	0.038	-0.076	-0.113
15-20	-0.293	-0.174	-0.114	-0.094	-0.005
P13 y					
0-5	-0.399	-0.497	-0.480	-0.343	0.008
5-10	-0.199	-0.140	-0.128	-0.147	-0.003
10-15	-0.058	-0.150	-0.194	-0.313	-0.158
15-20	-0.238	-0.231	-0.297	-0.156	-0.069
P14 y					
0-5	-0.203	-0.233	-0.149	-0.027	-0.046
5-10	0.016	-0.020	0.018	0.003	0.006
10-15	-0.046	-0.072	-0.059	-0.036	-0.009
15-20	-0.021	-0.078	0.016	-0.021	-0.019

P15 y					
0-5	0.049	0.033	0.037	0.042	0.020
5-10	-0.053	-0.068	-0.028	0.019	0.039
10-15	-0.037	-0.103	-0.022	0.031	0.043
15-20	-0.030	-0.075	0.005	0.040	0.087
P16 y					
0-5	0.366	0.222	0.189	-0.151	-0.461
5-10	0.036	-0.010	-0.049	-0.105	-0.304
10-15	0.199	0.076	0.060	-0.079	-0.108
15-20	0.127	0.038	0.042	-0.054	-0.084
P17 y					
0-5	-0.101	-0.079	-0.077	-0.124	-0.053
5-10	0.193	0.054	-0.195	-0.408	-0.168
10-15	0.166	-0.060	-0.432	-0.841	-0.483
15-20	-0.127	-0.154	-0.258	-0.237	-0.107
P18 y					
0-5	-0.577	-0.451	-0.345	-0.285	-0.212
5-10	-0.196	-0.150	-0.279	-0.145	-0.077
10-15	-0.163	-0.104	-0.088	-0.080	-0.103
15-20	-0.033	0.004	-0.068	-0.075	0.019
P19 y					
0-5	-0.097	-0.236	-0.135	0.055	-0.028
5-10	-0.316	-0.138	-0.161	-0.033	-0.100
10-15	-0.096	-0.181	-0.069	0.001	0.045
15-20	-0.014	0.022	0.061	0.065	0.147
P20 y					
0-5	-0.202	-0.243	-0.314	-0.101	-0.038
5-10	-0.145	-0.197	-0.093	-0.094	0.004
10-15	-0.160	-0.050	-0.051	0.099	0.127
15-20	-0.011	-0.023	-0.067	-0.140	-0.220
P21 y					
0-5	-0.324	-0.277	-0.127	0.086	0.156
5-10	0.024	0.033	0.015	-0.016	0.031
10-15	-0.025	-0.021	-0.038	-0.070	-0.151
15-20	0.366	0.149	-0.106	-0.126	0.005
P22 y					
0-5	0.022	-0.067	0.282	0.299	-0.010
5-10	0.016	-0.022	-0.100	-0.114	-0.142
10-15	-0.049	-0.046	-0.035	0.022	-0.147
15-20	-0.022	0.029	0.070	0.019	-0.090
P23 y					
0-5	0.351	0.264	0.260	0.257	0.111
5-10	0.214	0.272	0.338	0.306	0.216
10-15	0.282	0.250	0.336	0.207	0.072
15-20	0.064	0.033	-0.001	-0.026	-0.063
P24 y					
0-5	0.051	-0.110	-0.110	-0.308	-0.478
5-10	0.143	0.098	0.049	-0.330	-0.349
10-15	-0.108	-0.040	-0.126	-0.299	-0.120
15-20	-0.091	-0.183	-0.139	-0.384	-0.466

Table A-3: Slopes for each five minute block in each participant (n=24) in the z axis used to calculate stabilisation times.

Underlined values are those considered not stable (i.e. <-0.5 or >0.5).

	EOP	C2	C4	C7	T3
P1 Z					
0-5	-0.666	-0.363	-0.437	-0.209	-0.297
5-10	-0.134	-0.254	-0.103	-0.382	-0.289
10-15	-0.199	-0.272	-0.325	-0.418	-0.521
15-20	-0.179	-0.151	-0.228	-0.160	-0.217
P2 Z					
0-5	0.132	-0.165	-0.275	-0.355	-0.533
5-10	0.146	-0.117	-0.102	-0.107	-0.124
10-15	-0.085	-0.115	-0.120	-0.182	-0.119
15-20	-0.075	-0.067	-0.140	-0.202	-0.236
P3Z					
0-5	0.046	0.046	0.054	0.068	0.112
5-10	0.078	0.174	0.010	0.036	0.017
10-15	0.205	0.222	0.166	0.251	0.119
15-20	0.025	-0.011	0.048	0.026	-0.049
P4 Z					
0-5	-0.087	-0.255	-0.345	-0.465	-0.407
5-10	0.095	0.089	0.052	0.172	0.137
10-15	-0.038	0.090	0.073	0.035	0.121
15-20	0.046	0.024	0.032	0.034	0.048
P5 Z					
0-5	-0.332	-0.303	-0.176	0.087	0.010
5-10	0.161	0.203	-0.044	0.038	-0.135
10-15	-0.041	0.012	-0.077	-0.353	-0.180
15-20	0.195	0.052	0.088	-0.013	-0.073
P6 Z					
0-5	-0.189	-0.198	-0.279	-0.168	-0.111
5-10	0.012	-0.146	-0.165	-0.095	-0.034
10-15	0.020	0.086	0.057	0.131	-0.047
15-20	0.044	0.064	0.063	0.034	-0.030
P7 Z					
0-5	-0.440	-0.530	-0.471	-0.419	-0.242
5-10	-0.337	-0.460	-0.477	-0.412	-0.441
10-15	-0.839	-0.729	-0.547	-0.653	-0.141
15-20	-0.318	-0.206	-0.194	-0.158	0.004
P8 Z					
0-5	0.092	-0.021	-0.091	-0.279	-0.037
5-10	-0.039	-0.039	-0.120	-0.172	-0.192
10-15	0.046	-0.185	-0.185	-0.139	0.094
15-20	-0.084	-0.071	-0.087	-0.044	-0.138
P9 Z					
0-5	-0.844	-0.632	-0.419	-0.313	-0.039
5-10	-0.705	-0.569	-0.537	-0.554	-0.416
10-15	-0.378	-0.265	-0.061	-0.109	-0.082
15-20	0.084	-0.168	-0.245	-0.270	-0.389

P10 Z					
0-5	-0.675	-0.670	-0.569	-0.351	0.025
5-10	-0.199	-0.137	0.132	0.358	0.208
10-15	-0.110	-0.124	-0.194	-0.374	-0.664
15-20	-0.320	-0.361	-0.272	-0.114	-0.005
P11 Z					
0-5	-0.214	-0.365	-0.459	-0.539	-0.530
5-10	-0.368	-0.297	-0.405	-0.409	-0.444
10-15	-0.154	-0.325	-0.482	-0.519	-0.541
15-20	0.074	-0.059	-0.201	-0.378	-0.662
P12 Z					
0-5	-0.337	-0.337	-0.143	-0.018	0.060
5-10	0.016	-0.037	-0.081	-0.016	0.004
10-15	0.013	-0.086	-0.084	0.118	0.175
15-20	-0.104	0.041	0.113	0.011	0.068
P13 Z					
0-5	-1.207	-1.056	-1.023	-1.000	-1.275
5-10	-0.663	-0.460	-0.558	-0.544	-0.815
10-15	-0.252	-0.229	-0.322	-0.457	-0.671
15-20	-0.264	-0.295	-0.340	-0.421	-0.649
P14 Z					
0-5	-1.292	-0.737	-0.456	-0.266	0.013
5-10	-0.078	-0.042	-0.204	-0.188	-0.100
10-15	-0.074	-0.100	-0.052	-0.034	-0.053
15-20	-0.375	-0.216	-0.013	0.006	0.061
P15 Z					
0-5	0.260	0.206	0.166	0.123	0.010
5-10	0.297	0.186	0.060	-0.031	-0.007
10-15	0.256	0.234	0.075	0.010	0.022
15-20	0.116	0.149	0.125	0.143	0.213
P16 Z					
0-5	-0.139	-0.356	-0.183	0.188	0.428
5-10	0.539	0.329	0.512	0.738	0.638
10-15	0.391	0.214	0.214	0.282	0.191
15-20	0.489	0.330	0.268	0.305	0.103
P17 Z					
0-5	-0.314	-0.294	-0.385	-0.524	-0.486
5-10	-0.067	-0.082	-0.256	-0.781	-1.137
10-15	0.040	0.127	-0.308	-0.774	-0.746
15-20	-0.039	-0.038	-0.144	-0.169	-0.263
P18 Z					
0-5	-1.954	-1.464	-0.962	-0.624	-0.369
5-10	-0.276	-0.372	-0.620	-0.548	-0.433
10-15	-0.092	-0.126	-0.163	-0.131	-0.345
15-20	0.004	-0.077	-0.190	-0.174	-0.251
P19 Z					
0-5	0.076	0.025	0.068	-0.115	-0.055
5-10	0.069	0.269	0.125	0.045	0.140
10-15	0.207	0.135	0.199	-0.080	-0.003
15-20	0.135	0.112	0.149	-0.067	-0.300

P20 Z					
0-5	-0.449	-0.174	-0.189	-0.270	-0.252
5-10	-0.401	-0.444	-0.229	-0.360	-0.390
10-15	-0.150	-0.099	-0.096	-0.027	-0.135
15-20	0.037	-0.100	-0.181	-0.223	-0.149
P21 Z					
0-5	-0.844	-0.740	-0.418	-0.247	0.002
5-10	-0.445	-0.496	-0.448	-0.370	-0.292
10-15	-0.004	-0.039	0.025	0.103	0.038
15-20	-0.075	-0.214	-0.024	0.524	0.333
P22 Z					
0-5	-0.084	-0.196	-0.171	-0.304	-0.472
5-10	0.289	0.357	0.000	-0.093	-0.312
10-15	0.078	0.097	0.132	0.150	-0.181
15-20	-0.146	-0.010	0.029	-0.099	-0.026
P23 Z					
0-5	0.366	0.118	0.063	0.247	0.155
5-10	-0.014	-0.203	-0.063	0.163	0.160
10-15	0.147	0.282	0.360	0.339	0.256
15-20	0.126	0.038	0.031	0.045	0.072
P24 Z					
0-5	-0.001	-0.092	-0.104	-0.208	-0.431
5-10	0.076	-0.012	-0.021	-0.692	-1.449
10-15	-0.140	0.023	-0.139	-0.529	-0.954
15-20	-0.329	-0.201	-0.161	-0.607	-0.995

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