Research Article

Evaluation of pelvis postural systems in spinal cord injury patients: Outcome research

Serena Dattoli¹, Mariele Colucci¹, Maria Grazia Soave², Rita De Santis³,
Leandro Segaletti⁴, Claudia Corsi¹, Marco Tofani⁵, Donatella Valente⁶,
Giovanni Galeoto⁷

¹Sapienza University of Rome, Rome, Italy, ²Invacare Rome, Rome, Italy, ³Department of Anatomical, Histological, Forensic and Orthopedic Sciences, Sapienza University of Rome, Rome, Italy, ⁴CPO “Gennaro di Rosa” ASL Rome, Rome, Italy, ⁵Department of Neurosciences and Neurorehabilitation, Bambino Gesù Hospital, Rome, Italy, ⁶Department of Paediatrics and Child Neuropsychiatry, Sapienza University of Rome, Rome, Italy, ⁷Department of Public Health, Sapienza University of Rome, Rome, Italy

Objectives: Compare three commercially available postural systems to determine the best for treatment of patients suffering from spinal cord injury lesion below the cervical spine.

Design: Outcome Research.

Setting: Ambulatory.

Participants: Thirteen patients were recruited for this study between March 2016 and July 2016 from the Occupational Therapy clinic of “Policlinico Umberto I” hospital in Rome and Occupational Therapy of “CPO” hospital in Ostia. The patient samples consisted of eleven men (84.6%) and two women (15.4%). All the patient are suffering by SCI with a lesion below the cervical spine.

Intervention: We evaluate postural systems customized by three different companies. Patients tried each pelvis device for a duration of one week, after which they have been asked to fill in questionnaire concerning static stability, temperature, movement adaptability, transfers and dynamical stability during the activities of everyday life. The impact on the health status has been evaluated by means of a further questionnaire (Health Status Scale SF-12) submitted to the patients.

Outcome Measures: Quality of life and daily life activities.

Results: The analysis of the data from the questionnaire, along with those of objective nature associated with the mapping of the pressure due to weight distribution, has allowed the selection of the most appropriate clinical solution.

Conclusion: This study has allowed two significant conclusions: the central role of the interplay between the patient and occupational therapist in the decision role and the clear evidence that patients with spinal cord injury felt definite differences between cushion stability and were able to indicate a specific typology providing the best satisfaction.

Keywords: Spinal cord injury, Occupational therapy, Rehabilitation, Quality of life, Activity daily of life

Introduction

A major risk for patients with compromised mobility is the generation of ulcers due to the physical stress from prolonged sitting. Pelvis postural systems are therefore designed to help preventing ulcers, especially for victims of spinal cord injury (SCI).¹⁻⁴

SCI often lead to deficits (like those associated with sensitivity and motility, causing immobility, incontinence disorders, protein depletion) making these subjects high risk for ulceration and consequent infection. For this typology of patients, as a consequence of the Pascal principle, air has been identified as the most suitable “material” for the distribution of the pressure on the contact surface of the cushion.^{5,6}

Accordingly, one of the main causes of ulcers formation is thus prevented, since the occurrence of “hot spots” due to excessive weight load on a part of the

Correspondence to: Galeoto Giovanni, Sapienza Università di Roma, Piazzale Aldo Moro 5, 00185 Rome, Italy. Email: giovanni.galeoto@uniroma1.it

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seat is reduced. Previous studies addressed the same questions and indicated a specific typology of cushion as being significantly more efficient in compensating the adverse effects of sitting posture on pressure distribution.⁷

In order to clarify the reasons, underlying the criteria we have followed in elaborating the questionnaire, we remind that, previous investigation under scored that the pressure exerted by patients on the cushion, in a static position is less than the pressure exerted in a dynamic position.⁴ Furthermore, other studies indicated that dynamic pressure distribution plays a crucial role in both ulcer prevention and in ensuring an adequate postural alignment.^{4,8–10}

It is therefore necessary to compare specific pelvis postural systems, by pressure measurements exerted on the cushions in either static and dynamic positions, related to the performed activity.^{11,12}

In order to identify regions of high pressure during different positions, the use of a pressure mapping system is of particular importance, providing an effective tool for the therapist to evaluate the seating and the posture on the wheelchair. This mapping device visualizes, in real time, the uniformity of the pressure distribution on the contact surface,¹² either when the patient is in static position or performing an activity, thus adding a further element helping to identify the best tailored solution for the specific patient.

The sample of patients, we have considered in our study, are suffering by SCI with a lesion below the cervical spine.¹³ Since different seats influence the balance of the patients with SCI, determining deficit of the postural control,¹⁴ we selected various pelvic postural positioning systems to determine their effectiveness for comfort and stability of the patient.

It is furthermore worth stressing that our research has been also motivated by a recent study, which underscored the importance of shared decision making (SDM) among clinical practice and suggested that evidence-based patient choice for treatment should be common practice. The Authors stressed that, despite the recognized importance, not much progress has been made to effectively implement primary care settings. Evidence for their successful implementation and use in extending SDM in routine practice remains scarce.¹⁵

Despite the wide-reaching implications of SDM for decision making in healthcare, there is little background information that addresses how and if patient decision aids are effectively incorporated by practitioners into their routine practice.

The necessity of a shared decision becomes particularly important in relation to matters where there is

uncertainty about the risks and benefits of treatment options (Burgess Watson, D., *et al.* 2008 and references therein).¹⁵

These studies confirm the importance of enlisting patient choice to help meeting characteristics of the user and stress that using an overly general approach to implement support products is unlikely to lead to an optimal prescription for all.¹⁶

The consequence of a wise procedure involving either subjective and objective evaluations has two major consequences: the satisfaction of the users and an economical advantage, deriving from saving of expensive medical treatments of the ulcers and of the associated infections.

Occupational therapists are often involved in assessing the seating needs of the patients with spinal cord injury, one component of this process involves determining the appropriate use of wheelchair cushions and pressure relieving techniques in the prevention of pressure sores,¹⁷ considering at the same time the patient's comfort, that is not only statistically significant but is also of practical clinical usefulness.¹⁸

The central role of the patients in the decision process stems also from the fact that the raw determination of the minimal pressure conditions are not sufficient. It often occurs that the cushions indicated by the wheelchair users as the most comfortable, are not necessarily those providing the lowest interface pressures.¹⁹

A study comparable to ours was conducted in 2001, the Authors have compared the effectiveness of the short-term pressure-relieving ability of the three most commonly prescribed wheelchair cushions (Roho, Jay, Pindot) for a person with SCI. Data analyses indicated that the pressure sensors registered potential harmful levels at the buttock-cushion interface for all the cushions, except for the Roho cushion, exhibiting significantly lower values than those of the Jay and Pindot cushions. The Roho cushion was more effective in relieving pressure at the seating surface than the Jay and Pindot cushions.³

On the other side a different research shows that no one wheelchair cushion is universally effective for all persons and that individual evaluation and routine reassessment are essential in reducing the occurrence of pressure sores.²⁰ Regarding the pelvis postural systems, there is no evidence in the scientific literature of studies concerning the patients' satisfaction and about the associated feedback on quality of life.

The present study is an attempt in the direction of filling such a gap, it is aimed at fixing a protocol to establish a criterion to explore the above quoted issues. Furthermore, there are many commercially

available cushions consisting of foams, gels, air or a combination of these, but there is, however, only a little evidence available on their relative comfort performances that may help to guide an informed prescription.^{19,21,22}

The primary objective of this study is the test of three postural systems to identify which one is the best in the treatment of spinal cord injury with a lesion below the cervical spine. The cushions were compared according to comfort, pressure distribution, stability, postural alignment, weight, temperature and adaptability to the movement and to activities.

Design

Outcomes research.

Setting

Ambulatory.

Participants

The patients we included in this study during March 2016 – July 2016 from the Occupational Therapy clinic of “Policlinico Umberto I” hospital in Rome and Occupational Therapy of “CPO” hospital in Ostia.

Inclusion criteria: owner of a self-propelled wheelchair; able to use self-propelled wheelchair; able to perform transfers on his/her own; older than 18 years; suffering from spinal cord injury with lesion below the cervical spine.

Exclusion criteria: they are required to be free from other pathologies preventing the correct use of arms; the wheelchair should not be equipped with external motors or “force multiplier”.

Before being involved in the study, the patients have been requested to sign the informed consent to the treatment of occupational therapy and the treatment of personal data.^{23,24}

Figure 1 Roho Contour Select.

Tools

The tools used for the study were:

- **The three pelvis postural systems:** ROHO Contour Select (air) (Fig. 1), Invacare Matrix Libra (foam with fluid overlay) (Fig. 2), Jay Balance (foam with fluid overlay) (Fig. 3).
- **Boditrak and FSA system:** pressure-mapping system, important tool in the prevention of ulcers, it is able to detect the areas of higher pressure and consequently the risk to which the patient is subjected, measuring the pressure both static (S) and dynamic (D) and quantifying the horizontal axis of the pressure center (COP) and the vertical axis of the pressure center (CVP), all factors contributing to the formation of ulcers (Fig. 4).
- **Postural assessment:** It is a unique tool allowing the occupational therapist to identify deformities in the patient, to establish if they are permanent or reducible in order to prescribe the right postural system and tool for the patient. The postural assessment is divided into steps, the first two are: an evaluation of the clinical situation and the patient's needs and objective observations of the “natural” posture on the wheelchair, comparing it to the benchmarks, reported below (**Pelvis, Shoulder and upper limbs, Trunk, Lower limbs, Head**).

In order to provide a quantitative measure of how much the patient posture deviates from the reference parameters, we have defined the relative deviation (in percent) of how each segment of the body is close to the nominal benchmark. Accordingly, 100% confirms that the body is in the ideal posture.

Figure 2 Invacare Matrix Libra.

Figure 3 Jay Balance.

As reported in the introduction, two questionnaire have played a pivotal role in our study.

- SF-12:** specific self-report questionnaire on health status, it allows to describe to the patient his health status through 12 questions. The questions have indices regarding the physical health (PCS) and mental (MCS).
- Questionnaire on patient satisfaction:** This questionnaire, invented by us, has provided us with a tool to assess the satisfaction of the patients in using the different cushions, compared on the basis of stability, temperature, movement and activity adaptability, transfers, stability during movement and ADL. The questionnaire consisted of six items, each one with five possible answers based on the Likert scale method: completely unsatisfied, unsatisfied, unsure, satisfied, completely satisfied. Each answer option is associated with a value between one and five, where one is “completely unsatisfied” and five “completely satisfied”. To obtain an overview of participants “general satisfaction” the answers were averaged for each item.

Intervention

The collaboration with each patient lasted four weeks, with a single weekly meeting for assessment.

During the first meeting, we outlined the project, obtained informed consent and made a postural assessment in supine position. We used the postural assessment in two cases: in the first meeting to identify the patient’s deformations, establishing whether they are permanent or reducible, and then to acquire patient’s percentage that represents how much each segment of the body get closer to the ideal posture. We took the anthropometric measures in order to choose the right size of the cushions and we got information about the patient’s occupational history.

Every week, the participant used one of the three cushions at home (in a randomized order), carrying out his/her normal daily activity. To objectively evaluate the pressure distribution exerted by the patient on the postural system, a pressure mapping system (FSA) has been used in static position (after 30 seconds of sitting) and in a dynamic condition, assessed by making the patient to proceed on a straight line of 40 meters, with manual drive at top speed, analysing the maximum pressure exerted on the cushions during the propulsion.

After measuring the pressure, the posture of the patient was photographed and subsequently analysed by using the postural evaluation, compared to an ideal posture. After checking that the cushion did not determine a too high pressure, potentially harmful for the formation of ulcers, it was possible to proceed with its assignment for one week. After a week with the cushion, the patient evaluated it by filling in the two questionnaires SF-12 and the questionnaire about the satisfaction.

Analysis of data

In order to provide a reliable evaluation of which cushion participants perceived to be the best, according to pressure distribution, postural assessment, patient’s health status and patient’s satisfaction, we used a

Figure 4 Boditrack and FSA system.

Kruskal-Wallis Test (KWT) and a descriptive analysis for general information (age, sex, hours using their wheelchair). The KWT allowed us to calculate the “P-value” in order to establish if the data is statistically significant. The statistical analysis was performed through the statistic program SPSS version 21.

Outcome measures

The outcome measures are the quality of life and daily life activities.

Results

Thirteen patients were recruited for this study from March 2016 – July 2016. The patient samples consisted of eleven men (84.6%) and two women (15.4%); 7.7% of the patients using their wheelchair less than four hours per day, 7.7% of the patients using their wheelchair for four to six hours per day, 23.1% for six to nine hours per day and 61.5% of the patients using their wheelchair for more than nine hours per day.

Regarding the postural evaluation on the three cushions we noticed that an air cushion is less suitable to maintain corporal segments alignment after the activity especially for the alignment of the pelvis, trunk and shoulders (we obtained percentages of deviation from the ideal posture equal to 58.3% for the shoulders, 50% for the trunk, 33.3% for the pelvis), instead the head and the lower limbs are close to the ideal posture (for the head 91.7% and for the lower limbs 83.3%). A foam cushion (Jay Balance and Matrx Libra) is more suitable for the alignment of the corporal segments, especially the head (that is in the ideal posture, 100%), the shoulders and for the lower limbs, instead, also in this case, the pelvis and the trunk are not close to the ideal posture, though in a better alignment with respect to air (Table 1).

The SF-12 did not highlight PCS differences between the cushions, instead regarding the MCS, it obtained a border line value, $P = 0.05$ (Table 2).

Measuring the pressure in static and dynamic conditions shows that with an air cushion we obtained a lower pressure for the COP (Static: $22.67 \pm \text{SD } 1.614$, Dynamic: $22.17 \pm \text{SD } 1.528$) and CVP (Static: $24.42 \pm \text{SD } 4.641$, Dynamic: $24.92 \pm \text{SD } 4.738$) with respect to a foam one, instead for the mean, the distribution of the pressure on the contact surface, a foam cushion (Jay and Libra) obtained a lower value with respect to the air based counterpart (Table 3).

Regarding the questionnaires, we asked patients to further clarify some questions in order to understand

Table 1 Postural evaluation, we calculated in percentage how much each segment of the body get close to the ideal posture.

	ROHO	LIBRA	JAY
Head	91.7%	100%	100%
Shoulders	58.3%	91.7%	83.3%
Trunk	50%	66.7%	66.7%
Pelvis	33.3%	50%	66.7%
Lower limbs	83.3%	83.3%	91.7%

how the cushion has influenced the activities of daily living (Table 4).

Table 1. Postural evaluation: Using postural evaluation, we registered patient’s relative deviation from the ideal position after the activity. We compared the patient’s posture on each cushions with respect to a reference ideal posture (that is a posture that does not cause the formation of secondary damage), noting how much the posture deviates in percentage by reference parameters.

Table 2. SF-12: To highlight subjectivity in seat cushion choice, each patient, after using cushions, had to complete a SF-12 scale. We divided Physical Component Summary (PCS) and Mental composite score (MCS). This self-administered scale allows to describe the health status, and therefore also the patient’s quality of life, not only physical health but also the mental one. We gave the scale after every test week of the cushions.

Table 3. Boditrak and FSA system: We registered average pressure both static (S) and dynamic (D). In addition, we quantified the COP and CVP. We measured the pressure putting the Boditrak and FSA system on the seating surface of the analyzed cushion, either when the patient was not moving (static position) either when he was performing an activity (dynamic position).

Table 4. Questionnaire on patient satisfaction: Reported data constitute the item’s mean value. This questionnaire was invented by us and was formulated in order to put the patient at the center of the selection

Table 2 Average and SD of SF-12: Specific self-report questionnaire on health status, it allows to describe to the patient his health status through 12 questions.

ROHO mean $\pm$ SD	LIBRA mean $\pm$ SD	JAY mean $\pm$ SD	Kruskal Wallis Test (P-value)	PCS
43.42 $\pm$ 9.10	45.83 $\pm$ 5	42.50 $\pm$ 9.4	$P = 0.737$	
ROHO mean $\pm$ SD	LIBRA mean $\pm$ SD	JAY mean $\pm$ SD	Kruskal Wallis Test (P-value)	MCS
48.33 $\pm$ 10.6	56.58 $\pm$ 9.3	48.67 $\pm$ 9.11	$P = 5.989$	

Table 3 Average and SD of data collected by the Boditrak and FSA system (pressure-mapping system) in order to establish the risk to which the patient is subjected. Unit of measure: Torr.

STATIC	Roho Contour Select mean $\pm$ SD	Invacare MatrXLibra mean $\pm$ SD	Jay Balance mean $\pm$ SD	Kruskal Wallis Test (P-value)
MEAN (mmHg)	41.33 $\pm$ 12.2	39.58 $\pm$ 11.743	39.83 $\pm$ 16.348	P = 0.411
COP(cm)	22.67 $\pm$ 1.614	22.92 $\pm$ 2.151	2 $\pm$ 1.706	P = 0.379
CVP (cm)	24.42 $\pm$ 4.641	26.67 $\pm$ 4.499	24.83 $\pm$ 4.802	P = 2.390
DYNAMIC	Roho Contour Select mean $\pm$ SD	Invacare MatrXLibra mean $\pm$ SD	Jay Balance mean $\pm$ SD	Kruskal Wallis Test (P-value)
MEAN (mmHg)	51.08 $\pm$ 15.547	49.08 $\pm$ 15.180	45.08 $\pm$ 12.501	P = 1.251
COP(cm)	22.17 $\pm$ 1.528	23.17 $\pm$ 1.850	23 $\pm$ 2.523	P = 2.266
CVP (cm)	24.92 $\pm$ 4.738	26.33 $\pm$ 4.141	25.5 $\pm$ 4.964	P = 0.569

process, by investigating his opinion about: stability, temperature, adaptability to the activities, transfers, stability during ADL, stability in movement. Also this questionnaire was administered to the patient after every test week of the cushions (Appendix A).

Discussion

Several studies have analyzed the prevention of pressure ulcers, especially in people with spinal cord injuries,¹⁻⁴ but regarding the pelvis postural systems there is no evidence in the scientific literature of studies concerning the patients' satisfaction and about the associated feedback on quality of life. Therefore this study is meant to represent a step forward in filling such a gap.

After measuring the pressure in static and dynamic modes,^{2,4,11} through pressure mapping system,¹² we analyzed the mean of the pressure and it suggests that a cushion composed with foam determines a better distribution of pressure during static and dynamic positions. Conversely, using different metrics rather than, regarding the center horizontal of pressure and the center vertical of pressure, we confirm again the evidence reported in the literature that an air cushion is considered the best for the prevention of the ulcers (Table 3).^{3,5}

All three cushion systems did not significantly change the postural alignment pre- and post- activity and patients indicated they were less able to maintain stability with an air cushion compared to those made of foam (Table 1). Additionally, there are no statistically significant differences between the results of the SF-12 scale, even though we obtained a border line value (MCS equal to P = 0.05) in favor of the Invacare Matrix Libra.

In order to put the patient at the center of the decision process,¹⁵ and in order to avoid a too general approach to the prescription,¹⁶ we analyzed also the satisfaction of the patient by using the different cushions (Table 2): we found statistically significant differences only in the case of the stability felt by the patient during the trial period of the cushion, instead all the other items of the questionnaire produced results greater than or equal to P = 0.05. Regarding the stability we obtained a "P-value" equal to 0.041 (Table 4), in favor of the Invacare MatrX Libra.

Moreover, albeit not statistically significant, we noticed that for all the items of the questionnaire the patients showed more satisfaction by using the cushion Invacare MatrX Libra compared to the others.

Table 4 Average and SD of the Questionnaire on patient satisfaction: We assessed the satisfaction of the patients in using the different cushions, compared on the basis of stability, temperature, movement and activity adaptability, transfers, stability during movement and ADL.

	ROHOMean $\pm$ SD	LIBRAMean $\pm$ SD	JAYMean $\pm$ SD	Kruskal Wallis Test (P-value)
Stability	3.08 $\pm$ 1.165	4.17 $\pm$ 0.937	4 $\pm$ 0.853	P = 6.372
Temperature	3.75 $\pm$ 0.754	4.17 $\pm$ 0.937	3.83 $\pm$ 1.115	P = 2.127
Adaptability to the activities	3.50 $\pm$ 1.243	3.873 $\pm$ 1.267	3.75 $\pm$ 1.138	P = 0.637
Trasfers	3.5 $\pm$ 1	4.33 $\pm$ 0.651	4.08 $\pm$ 1.24	P = 4.258
Stability during ADL	3.5 $\pm$ 0.905	4.17 $\pm$ 0.937	3.92 $\pm$ 0.9	P = 3.417
Stability in movement	3.5 $\pm$ 1	4 $\pm$ 0.953	3.83 $\pm$ 0.835	P = 1.756
Total questionnaire	20.83 $\pm$ 0.158	24.67 $\pm$ 0.198	23.41 $\pm$ 0.112	P = 2.895

Conclusions

From this study emerges that all three cushions analyzed are optimal solutions for patients with spinal cord injury using self-propelling wheelchair.

In order to understand more completely how subjective the choice of wheelchair cushion is, we should increase the study sample size, because a small one does not allow many statistically significant differences.

Disclaimer statements

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Conflict of interest The authors report no conflicts of interest.

Statement of human and animal rights All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008 (5). Informed consent was obtained from all patients for being included in the study.

Statement of informed consent Informed consent was obtained from all individual participants included in the study.

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Implications for occupational therapy practice This study highlighted how to do an optimal posture system prescription, other than taking into account pressure ulcers prevention and postural assessment, it should be essential to consider patient's point of view, cushion's adaptability during activities and general patient's satisfaction about comfort and health status, this way patient's needs, along with therapist's experience and assessment tools, would certainly lead to an optimal posture system choice.

Before closing the paper it is worth stressing the limits of our study, which are mainly associated with the exiguity of the patient sample. The statistical significance of the analysis should be therefore improved in terms of a larger attendance to the trial.

It would be interesting to improve our data using a larger number of patients and slightly change in the protocol. In particular we should envisage a procedure to determine general criteria leading to the definition of a set of parameters allowing the production of spreadsheets for the calculation of the most appropriate

comfort indices. Further investigations could be developed along such a direction.

ORCID

Giovanni Galeoto <http://orcid.org/0000-0002-9043-5686>

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Appendix A

Questionnaire on patient satisfaction

1. Age:
2. Gender:
 - ☐ Male
 - ☐ Female
3. Which postural unit currently uses *?
 - ☐ Trunk(backrest and cushion)
 - ☐ Pelvis (cushion)
 - ☐ Trunk-Pelvis (backrest and cushion)
 - ☐ No one

* Specify the postural system model if used (air, foam, etc.) _____
4. In what structure did you benefit from the postural basin unit provided during the test week?
 - ☐ Hospital
 - ☐ Assistant Sanitary Residence
 - ☐ rehabilitation center
 - ☐ Hospice
 - ☐ Domicile
 - ☐ None of the previous ones
5. Use orthoses or lower limb guards to change his posture in a wheelchair?
 - ☐ Yes
 - ☐ No
6. In what temporal range does the average time spent by her in the wheelchair fall?
 - ☐ 1 to 4 hours
 - ☐ 4 to 6 hours
 - ☐ 6 to 9 hours
 - ☐ More than 9 hours

7. How do you do the transfers?

- ☐ autonomously without aids
- ☐ autonomously with aids
- ☐ with assistance
- ☐ With lifter
- ☐ None of the previous ones

8. Give a judgment to the following cushion in terms of:

• STABILITY:

Completely satisfied	Pretty / quite satisfied	Unsure	Pretty / rather unsatisfied	Completely unsatisfied
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• Constant maintenance of TEMPERATURE:

Completely satisfied	Pretty / quite satisfied	Unsure	Pretty / rather unsatisfied	Completely unsatisfied
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• Adaptability to movement and activities:

Completely satisfied	Pretty / quite satisfied	Unsure	Pretty / rather unsatisfied	Completely unsatisfied
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• Facilitate wheelchairs-bed / bed-wheelchairs TRANSFERS:

Completely satisfied	Pretty / quite satisfied	Unsure	Pretty / rather unsatisfied	Completely unsatisfied
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• STABILITY IN SHORT DISTANCES ON A SPEED RETREAT (40 m):

Completely satisfied	Pretty / quite satisfied	Unsure	Pretty / rather unsatisfied	Completely unsatisfied
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• Stability during SMALL PERSONAL HYGIENE (beard / make-up, face and teeth washing):

Completely satisfied	Pretty / quite satisfied	Unsure	Pretty / rather unsatisfied	Completely unsatisfied
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