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How different seats impact on spinal cord injury (SCI) subjects

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Summary
Seating Acquired Pressure Ulcers (SAPU) in SCI population are very frequent. Many high quality material cushions of different technologies address PSU prevention, but it is unclear the effectiveness arising from the use of a pressure relief cushion instead of a postural one. The choice depends on comfort, durability, postural stability and functionality.

Aims and Objectives
The aim of this study is to understand which parameters lead to define the criteria of choice for a specific technology, either being the combination of different technologies and materials, or the combination of all the above with a specific design of cushion. Then verify if and how these criteria influence the biomechanics of user, their functional performance and perception.

Background

MATERIALS AND METHODS
Participants were divided in two groups:
In group 1 five able-bodied (2 men and 3 women), in group 2, five subjects with SCI (3 men and 2 women); written informed consent was obtained.
Materials: 2 wheelchairs in different sizes of the same model Cv Avantgarde Otto Bock, 2 wood bases to rigidify the seat and the back in 2 different sizes, 2 groups of cushions A (pressure relieve) and B (postural) divided in three sub groups (different technologies and materials) A1 Air-Roho6LP, A2 Polymeric/Fluid- Jay Xtreme, A3 Polymeric combined- Inserto Modo, B1 Air-RohoQuadto, B2 Polymeric/Fluid-Jay 2, B3 Polymeric combined - Inserto Novo. One surface EMG with wireless sensors 8 channels mod. Free EMG BTS, gait analysis instrumentation with 6 synchronized infrared cameras with sample frequency 250 Hz and 2 video-cameras mod. El.I.Te.Smart Dx BTS, a pressure mapping system NOVEL PLIANCE (a flexible measuring mat, a multi-channel analyser, a calibration device and a software package for PCs), standard ISO 16840-1:2006.

STUDY DESIGN
Three observation moments were established: T0, T1(15 minutes by T0), T2 (30 minutes by T0), for the statics and dynamics moments. During the dynamic phase, the subjects propelled along 10 meters four times (total distance 40 meters, total sitting time for subject on each cushion 45 minutes). Using the ISO 16840-1:2006 a protocol was established to standardize the biomechanical data recording process for wheelchair seated persons. At the beginning all data were collected for the sample using the wheelchair with wood basis for seat and back mounted to reach the seated reference position (90°beetwen trunk and pelvis, femur and tibia and leg and foot).
Data recorded were:

- Biomechanics: three absolute angles of body segments (α frontal pelvic angle, β sagittal pelvic angle and γ sagittal trunk angle);
- Interface pressure mapping: mean pressures, mean areas, mean forces were detected during the three times both for static and dynamic.
- Emg: to analyse the muscular activity and muscular coordination (m.gluteus, m.rectus abdominis, m.erector spine, m.tricepts);
- Questionnaire: to detect the comfort and stability perception, fixing a numeric score between 0 (lowest) and 5 (highest).

Results

BIOMECHANICS
FRONTAL PELVIC ANGLE α (Pelvis Obliquity)
Benchmarks: values ›270°‹360° refers to a right obliquity, values ›0°‹90° refers to a left obliquity, value = 0° indicate neutral position.
Average values closer to 0° within 3 observational statics time for cushions in group A were reached by Roho 6LP (3.13°) and for cushions group B by Inserto Novo (1.35°). Average values closer to 0° within 3 observational dynamics time for cushions in group A were reached by Jay Xtreme (5.06°) and for cushions in group B were reached by Roho Quadtro (5.28°) as well as Inserto Novo (5.36°).
PELVIC ANGLE β (Pelvis Tilt)
Benchmarks: β<40.7°refers to a posterior pelvic tilt, *β >40.7 refers to an anterior pelvic tilt*, *β=40.7°refers to a neutral position.*
Average values closer to 40.7° within 3 observational statics time for cushions in group A were reached by Jay Xtreme (43.23°) and for cushions in group B by Inserto Novo (58.70°). Average values closer to 40.7° within 3 observational dynamics time in cushions group A were reached by Inserto Modo (40.33°) and for cushions in group B were reached by Roho Quadtro (40.34°) as well as Inserto Novo (39.69°) .
SAGITTAL TRUNK ANGLE γ (Trunk Vertical Balance)
Benchmarks: γ>90° refers to a posterior trunk inclination, γ<90°refers to an anterior trunk inclination, γ=90° refers to a vertical balance. It is advisable to correlate values of γ° with values of β°.
Average values closer to 90° within 3 observational statics time for cushions in group A were reached by Inserto Modo (86.68°) and for cushions in group B by Inserto Novo (89.19°). Average values closer to 90° within 3 observational dynamics time in cushions group A were reached by Jay Xtreme (96.76°) and for cushions in group B by Inserto Novo (92.80°).

INTERFACE PRESSURE MAPPING
AVERAGE PRESSURE WITHIN STATICS AND DYNAMICS OBSERVATIONAL TIME ON THE SEATING SURFACE *(mmHg)*:
Lowest pressure values in cushions group A were reached by Roho 6LP (117.03), values of (141.68) were reached by Jay Xtreme as well as Inserto Modo (145.65).
Lowest pressure values in cushions group B were reached by Roho Quadtro (105.43); values of (120.31) were reached by Jay2 as well as Inserto Novo (127.48).
AVERAGE CONTACT AREA WITHIN STATICS AND DYNAMICS OBSERVATIONAL TIME DETECTED BY SENSORS ON THE SEATING SURFACE *(cm^2)*:
Highest contact area values in cushions in group A were reached by Jay Xtreme (690.05).

Highest contact area values in cushions in group B were reached by Roho Quadtro (770.16)
AVERAGE OF ALL THE VERTICAL FORCES EXERTED BY THE BODY ON THE SEATING SURFACE IN RELATIONSHIP WITH THE PRESSURE AND CONTACT AREA WITHIN STATICS AND DYNAMICS OBSERVATIONAL TIME (*N*):
Lowest forces values in cushions in group A were reached by Inserto Modo (295.18) and highest forces by Jay Xtreme (365.25).
Lowest forces values in cushions in group B were reached by Inserto Novo (279.90) and highest forces by Jay2 (335.04).

ELECTROMYOGRAPHY
The EMG data have showed a correlation with biomechanics data and this matter needs further investigation and study.

QUESTIONNAIRE
The highest score related to the perception of comfort and stability for cushions in group A Jay Xtreme (3.8) and for cushions in group B Inserto Novo (4).

Discussion

Results of this study suggest that the whole asset design, technology, cushion materials influences user' biomechanical modifications. Biomechanical modifications in turn influence functional performances, pressure loads, and the perception of the comfort and stability. For this to happen, cushion need to be personalized.
Analyzing pressure data, helps better understand the performance of the asset design, technology and cushion materials.
There are however, several other criteria to rely upon either then just pressure parameters which are interfered by cushion design, the material used both for the cushion and cushion cover, the material the mat is made of, sensor features, user morphology and the configuration of the wheelchair.
The following better guarantee the integrity of choice: assessment of the user, cushion customization, perception of comfort and stability and the visual observation of skin.
Pressure results, are the important markers of the body stability reached by user in the time intercurrent between static/dynamic phases and during propulsion and functional activities. These results are also useful to understand the performance of material and technology as the cushion is being used.
A contoured design of the cushion, whatever the technology of the material, involves a balance between the stability of the pelvis and trunk improving the coordination of movement, minimizing and/or inhibiting pelvic instability on frontal and sagittal planes. The design of the cushion builds a proximal support (anterior-posterior and lateral of the pelvis) improving the manual ability and facilitating the sitting position during the time as the related activities, making it safer, effective, economical and comfortable. Combining the different technologies, materials and design, shows that, in order to prevent both the SAPU and deformities, the materials used must carry the capability to adapt and adjust continuously during the user activity.

References

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