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Settling down time following initial sitting and its relationship with comfort and discomfort

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Abstract This study examined the subjective rating of wheelchair comfort and discomfort (numerical rating scale questionnaire) and the duration of objective in-chair movement reduction "settling down time" following initial contact with the seating surface. Healthy young subjects ($n = 22$) sat for 5 min on contoured foam or wood cushion surfaces fitted to otherwise identical wheelchairs. Force sensing resistors attached to each quadrant of the sitting interface measured the relative movements of the subjects over time.

A significant correlation was found between settling down time (SDT) and reported leg/feet discomfort ($p = 0.003$; correlation co-efficient $= 0.44$); and a significant negative correlation was found between SDT and overall comfort ($p = 0.015$; correlation co-efficient $= -0.36$). When comparing cushion surfaces: SDT was significantly longer ($p < 0.0001$) for subjects sitting on wood (5.8 s) compared to contoured foam (3.9 s); Leg/feet discomfort was significant higher ($p = 0.007$) for subjects sitting on wood (1.1 out of 10) compared to contoured foam (0.3 out of 10); Overall discomfort was significant higher ($p = 0.009$) for subjects sitting on wood (1.3 out of 10) compared to contoured foam (0.5 out of 10); Comfort was significantly lower ($p = 0.001$) for subjects sitting on wood (6.5 out of 10) compared to contoured foam (8.3 out of 10); Support was significantly lower ($p = 0.001$) for subjects sitting on wood (6.4 out of 10) compared to contoured foam (8 out of 10).

The results of this study suggest that the shape and firmness of the surface at the buttock–wheelchair interface can affect a subject's SDT following initial contact with the seat as well as their perception of comfort and discomfort. In addition, there appears to be a relationship between longer SDT's and increased discomfort ratings, and shorter SDT's and increased comfort ratings. Therefore, testing for SDT's may be useful in the indirect objective assessment of wheelchair cushions

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and possibly other types of seating surfaces with design differences that aim to improve comfort and minimize discomfort.

Introduction

Seating comfort has been associated with softness and support [13,17,31,32,46,59,66,69], while discomfort has been related to lack of support, uneven pressure distribution and fidgeting associated with biomechanical and fatigue factors [15,17,28,31,32,46,48,49,59,64,66,67,69].

Previously, in-chair movement (ICM), pressure distribution, postural and biomechanical parameters and MRI studies of relevant anatomy have all been used to determine the effects of sitting in chairs on the body [1,8,9,11,12,27,30,34,38,40,41,54,55,58,60,61,65,66,68]. How anatomical factors may lead to characteristic tissue loading patterns that appear to be associated with tissue damage, discomfort or modifications of in-chair posture or movement are of particular interest to this study.

When an individual sits on a hard flat surface, their body weight loads the buttocks which in turn undergo a change in shape, non-homogenous tissue deformation, and internal tissue strains and stresses [42,52]. In this weight bearing sitting posture, the ischial tuberosities move down towards the sitting surface with maximum tissue strains and stresses occurring in the gluteal muscle tissue where they interface with the ischial tuberosities, and not in the fat or skin near the body—seat interface [23,42,51,52,58].

Anatomical differences in the shape of the ischial tuberosities (e.g. sharp normal variants or pathoanatomical changes seen in paraplegics exposed to chronic sitting), increased trunk weight and decreased gluteal muscle thickness (e.g. paraplegics) are associated with increased buttock tissue strains and stresses which appear to increase susceptibility to deep tissue injury [42,43].

Following excessive or sustained tissue loading, cell death may result in the development of a superficial or deep pressure sores [4,42]. A superficial pressure sore first affects the layers of skin near epidermal tissue and is typically associated with the presence of moisture and heat combined with damaging frictional and shear forces [16]. In contrast, deep pressure sores typically begin with deformation of the deep muscle and fat tissues under the ischial tuberosities in the sitting position [5,7]. Although the aetiology of pressure sores are multi-factorial [24,39], sustained pressure at the user—seat interface is considered to be the most significant factor [6,10,18,21,22,24,25,33,37].

For the above reasons, much effort has been dedicated to alleviating pressure under the ischial tuberosities, which has lead to the appearance of a wide variety of wheelchair cushions on the market [6,24,57]. When designing a wheelchair cushion, there is a great deal of data in support of the importance of reducing pressure over the ischial tuberosities as much as possible by redistributing it more homogenously over the buttocks through maximizing the contact surface at the buttock—seat interface [14,24,29,45,62,63].

As these internal tissue loads are posture dependent, they may also be alleviated with an appropriate active or passive change in posture [43,58,63]. Active movements by the user are therefore recommended to provide periods of pressure relief, however, if this is not possible, some wheelchairs and wheelchair cushions assist in redistributing this pressure by passively mobilizing the user [6,53,58,62,63].

Outside the wheelchair setting when a person first sits down they appear comfortable and move little, however, over time (45—180 min) increasing discomfort appears to lead to significant increases in in-chair movements [2,3,19,26,35,36,47,56]. Infrequent in-chair movements (ICM's) during prolonged sitting have long been considered to be a primary risk factor in the development of work related musculoskeletal disorders [20,50], whilst conversely, frequent ICM's have long been considered to be related to sitting discomfort [3,20,26]. It is has been hypothesised that there could be a balanced amount of ICM's that does not lead to risk of injury or discomfort [20]. Sitting in chairs with obvious design differences (e.g. wooden versus padded) appears to significantly effect ICM's in most cases [19,26,44] but not all [35]. As users subconsciously change their posture to minimize the effects of discomfort while sitting, discomfort is not obviously perceived unless the chair severely compromises basic design criteria [32]. ICM's have demonstrated two types of motion: smaller more frequent movements resembling postural sway and larger less frequent movements that appear to be major changes in posture. These movement patterns seem to be stable over