COMPARATIVE KINEMATIC ANALYSIS OF SIMILARITIES AND DIFFERENCES IN SERVE AND GROUNDSTROKES BETWEEN WHEELCHAIR AND STANDING TENNIS PLAYERS

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The purpose of this study was to clarify differences in the shoulder range of motion (ROM) between wheelchair users (WU), wheelchair (WTP) and standing tennis players (TP) and differences in shoulder angles between wheelchair and standing tennis players during tennis groundstrokes and serve. 4 wheelchair users, 5 wheelchair tennis players, and 4 able-bodied tennis players served as subjects. For analysis of shoulder range of motion (ROM), internal, external and total ROM data of all subjects were collected. The tennis movements serve, backhand slice, and forehand topspin were recorded of WTP and TP. Kinematic data were collected by eight cameras and included shoulder angles of the dominant arm: anteversion, abduction and internal rotation. Statistical analysis of kinematic data showed significant differences during almost all movements between WTP and TP. Different shoulder angles and ROM might be important findings for shoulder pathology and wheelchair tennis training skills, especially flexibility training.

KEY WORDS: wheelchair tennis, shoulder range of motion, shoulder angles

INTRODUCTION: Wheelchair tennis players (WTP) have different playing conditions compared to standing tennis players (TP) due to locomotion and injury. Many studies, however, deal with shoulder injury in SCI patients (Finley et al., 2004, Samuelsson et al., 2004), but hardly any study can be found dealing with wheelchair tennis and shoulder problems in WTP.
WTP are at high risk of shoulder injuries (Burnham et al., 1993; Finley et al., 2004). Especially overhead activities cause pain and are often avoided by WTP.
Spinal cord injury, though, may influence kinematics in tennis. Muscle weakness and lesion level might affect trunk stabilisation and stroke technique in wheelchair tennis. Consequently, WTP would have to find compensatory mechanisms to achieve optimal stroke technique and to optimise performance. Furthermore, shoulder pathology is also an essential aspect in wheelchair tennis due to high occurring loads and common shoulder injuries in tennis players. Two reasons for increased shoulder injury risk are common muscle imbalance and decreased shoulder range of motion. So shoulder angles during tennis strokes and glenohumeral range of motion have been analysed to compare kinematics and ROM between WTP and TP.

METHODS: 3 male and 1 female wheelchair users, 5 male wheelchair tennis players (mean ITF ranking 41.5), and 3 male and one female able-bodied tennis players (Austrian National League) served as subjects.
To get to know flexibility conditions in wheelchair tennis players, internal, external and total shoulder range of motion (ROM) was measured of the dominant side in WU, WTP and TP. Total shoulder ROM was calculated by adding the internal and external ROM measurements together.

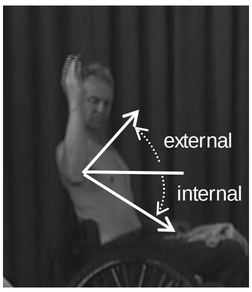

Figure 1: Glenohumeral rotation

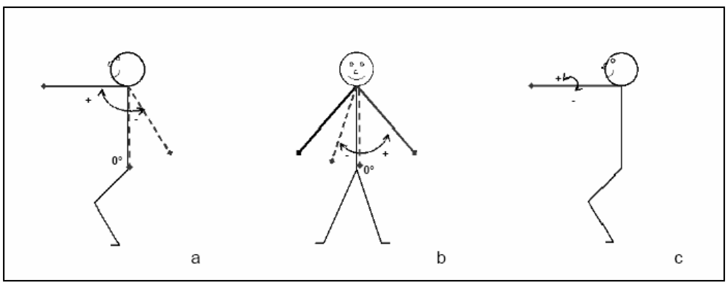

Figure 2: Shoulder angles a) anteversion, b) abduction, c)

internal rotation

Kinematic data were collected with eight cameras (Vicon System) keeping track of reflective markers placed on the trunk and arm.

Data included the range of shoulder angles of the dominant arm: anteversion, abduction and internal rotation of the humerus with respect to the thorax.

T-test was used for significance testing of the mean differences in shoulder angles between WTP and TP (alpha = 0.05). For significance testing of ROM, a one-way ANOVA was performed (WTP x TP x WU).

RESULTS: Results of the analysis of the glenohumeral rotation range did not show neither a significant difference in external, nor in internal rotation range. Statistical analysis of the total ROM, however, showed significant differences between WTP and TP (p <0.05*).

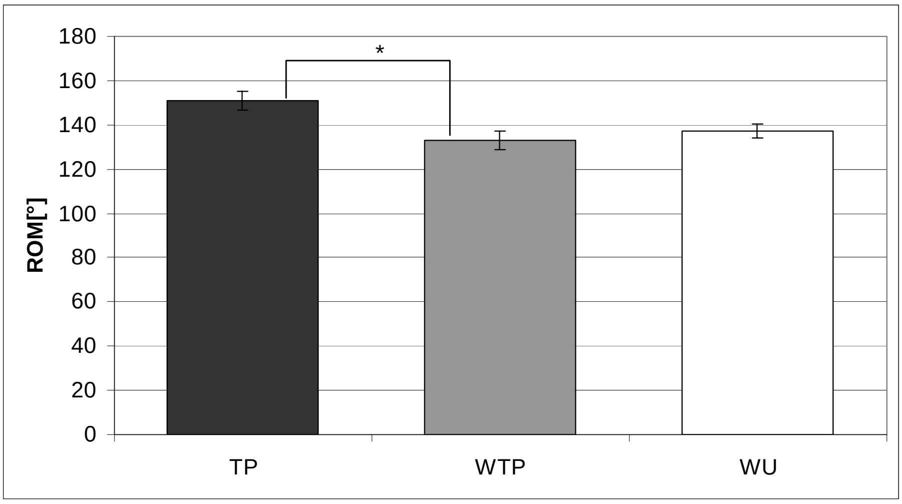

Figure 3: Total shoulder range of motion

Range of abduction (backhand p=0.001**, serve p<0.001***) and anteversion (backhand p<0.001***, forehand p<0.001***, serve p<0.01**) angles differed significantly during all three movements, whereas results for the range of internal rotation angle did not apart from the serve (p<0.001***). WTP had a significantly greater range of shoulder anteversion. Figure 4 shows results of the range shoulder angles during the backhand, forehand, and the serve.

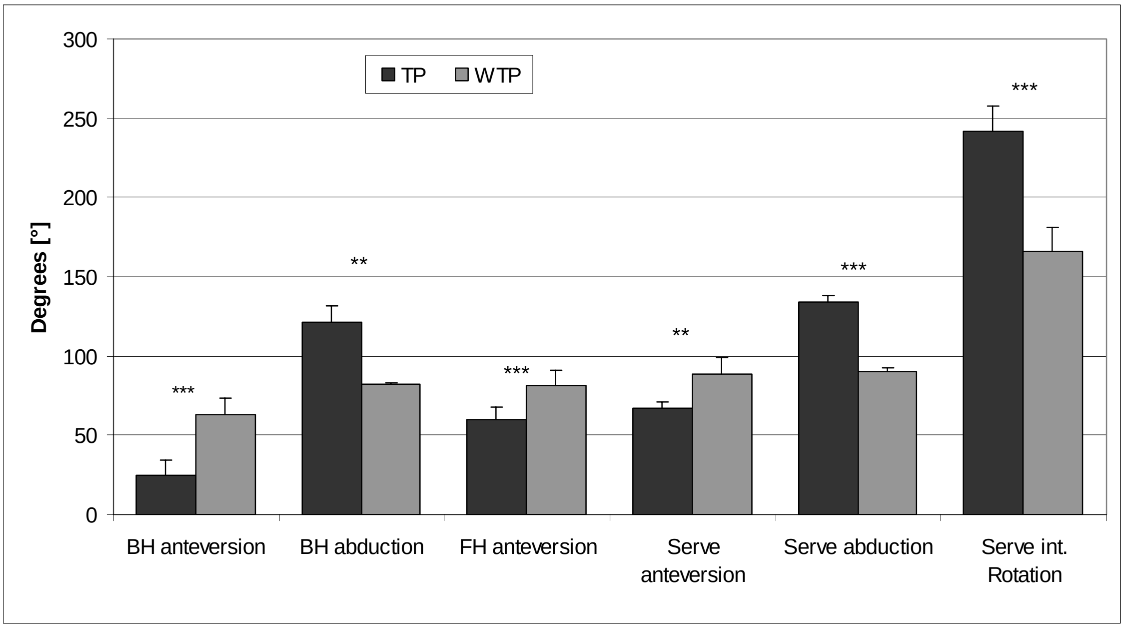

Figure 4: Range of shoulder angles during tennis strokes

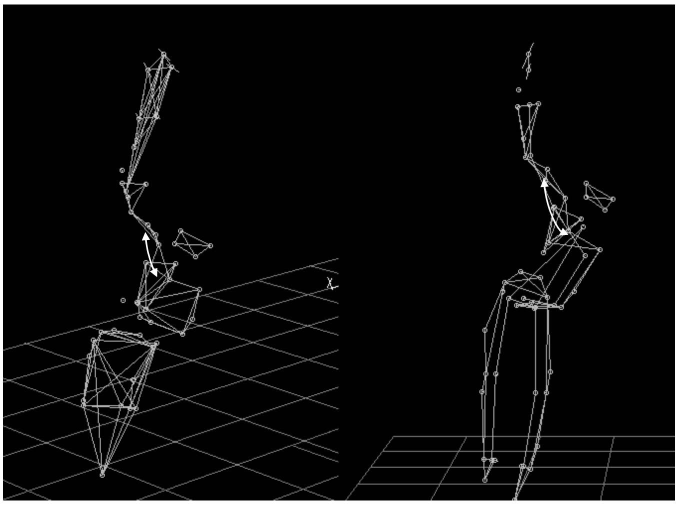

Figure 5: Shoulder abduction during the serve

DISCUSSION: This study was designed to assess shoulder angles during tennis strokes and shoulder range of motion.

Although WTP are in a lower position (sitting), they have lower abduction angles. This result shows that WTP make a lower loop during backward swing and must have other compensatory mechanisms for optimal acceleration of the racquet head.

Another interesting finding is the lower maximum of anteversion during tennis strokes. This result is more interesting when remembering increased range of anteversion. However, a higher minimum of anteversion means higher loads in the shoulder joints and shoulder muscles. When the humerus is in maximal retroversion, high tension and loads occur on the shoulder. These loads are unfavourable for joint and soft tissue.

For wheelchair tennis, it is interesting that there are significant differences in anteversion and abduction. Trainers have to analyse their players' techniques and should then find a way to reduce the range of anteversion. A great range of anteversion causes a lot of stress on the shoulder joints and athletes would be at high risk of injury.

Apart from anteversion and abduction, internal rotation showed no significant differences, except from the 1st serve. This is also very interesting because Malone et al. (2003) reported compensatory mechanisms in wheelchair basketball players to optimise their shot performance and to compensate impaired stabilisation. However, there could not have been shown significant differences in internal rotation between WTP and TP. During the serve internal rotation range was lower in WTP than in TP. This difference could be caused by trunk flexion in WTP during the backswing that may not afford a higher internal rotation angle of the dominant arm for an optimal serve. On the other hand this result could be a consequence of decreased total glenohumeral rotation range.

The finding that total shoulder range of motion differs significantly between WTP and TP was also reported in studies of Ellenbecker et al. (2002), Schmidt-Wiethoff et al. (2004) and Kibler et al. (1996).

So, if decreased total ROM is thought to be a factor of increased injury risk, WTP and WU in general are put at a very high risk of shoulder injuries because their range of motion is significantly below TP's rotation range.

Despite differences in motion and conditions, training skills are almost the same between TP and WTP. This could lead to critical loads on WTP and unfavourable playing/training conditions. Thus, trainers have to focus on adequate training programs which should include certain skills to cope with different conditions among WTP.

Furthermore WTP themselves should try to find their own way to improve their play in spite of doing TP's exercises.

For wheelchair tennis it is important to find special training and prevention programs that take into consideration different conditions (muscular etc.). WTP and TP differ in almost all aspects examined in this study, thus training must be adapted to these differences. An adaptation of training skills could eventually decrease injury risk and help WTP to improve or maximise their performance.

CONCLUSION: The findings of this study suggest several important aspects about shoulder joint motion. Although being in a lower sitting position, WTP perform less abduction angles. Range of anteversion angle is, however, increased in WTP. This could be a strategy to find the best combination of anteversion and abduction angle producing the greatest consistency and accuracy in their strokes. Furthermore results of this study could be an important finding for physiotherapists and trainers. Differences in stroke kinematics have to be considered in training programs and schedules in order to decrease injury risk. From this study, we can further understand the role of flexibility and joints in the upper body (shoulder), with a view to improve stroke efficiency and avoid sports injury.

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