Anaerobic Performance of Active and Sedentary Male Individuals With Quadriplegia

Natalia Morgulec and Andrzej Kosmol
Academy of Physical Education, Warsaw, Poland

Yves Vanlandewijck
Katholieke Universiteit Leuven, Belgium

Elzbieta Hubner-Wozniak
Academy of Physical Education, Warsaw, Poland

The purposes of this study were to compare the anaerobic performance of 19 active and 12 sedentary individuals with quadriplegia on the Wingate arm ergometric test and to investigate the relationship between participants’ demographic information (lesion level, time since injury, age, body mass) and their anaerobic performance variables. The following parameters were measured: peak power (PP), mean power (MP), lowest power (LP), time to achieve PP (t), fatigue index (FI), relative values of PP and MP with respect to body mass, and postexercise blood lactate accumulation (LA). Lowest power, MP, relative values of MP (rMP), FI and LApeak in the active group were significantly higher than in the sedentary group. There was a significant correlation between rMP and injury lesion level \((p = .016)\). It was concluded that for active individuals with quadriplegia, muscle endurance (MP) and fatigability (FI) are higher than for sedentary individuals with quadriplegia.

Spinal cord injury (SCI) results in impairment or loss of motor and/or sensory function in the trunk and/or extremities due to the damage to neural elements within the spinal canal. Injury to the cervical segments (C1-C8) results in quadriplegia, which causes an impairment of function in the arms, trunk, legs, and pelvic organs (Bromley, 1998; Figoni, 1997). The number of SCI cases reported each year varies in different countries, but the ratio of persons with quadriplegia to persons with paraplegia, as well as gender prevalence are comparable among developed countries. Approximately 50% of individuals with spinal cord injury have quadriplegia, and about 80% are males (Kiwerski, 1997; Steadward, 1998; Stover & Fine, 1987).
At the most fundamental biological level, the initiation of all movement is an anaerobic process. The anaerobic energy system is involved in providing energy for all forms of physical activity (Cahill, Misner, & Boileau, 1997). Many daily activities and sports events requiring short-term intense effort depend on anaerobic fitness (Bar-Or, 2003). The data reported by Bouchard, Taylor, Simoneau, and Dulac (1991), Patton and Duggan (1987), and Serresse et al. (1989) have shown there are differences in anaerobic power and capacity between sedentary individuals and athletes in the able-bodied population. It has been concluded that training increases short-, intermediate-, and long-term anaerobic power and capacity in the able-bodied population.

Anaerobic performance of able-bodied people is related to body mass and muscle size (Bouchard et al., 1991). The muscle mass available for activities in persons with quadriplegia is smaller than in able-bodied individuals. The higher the level of spinal cord injury, the greater the number of paralyzed muscles below the level of injury. Functional independence is also more limited. Quadriplegia results in limited venous return and cardiac output because of the lack of a muscle pump (Eggers et al., 2001; Fielding & Bean, 1999). In addition, there are disturbances in regulation of blood flow that result in abnormal redistribution of blood flow to active muscles. These disturbances impact muscle metabolism, can limit energy supply, and may result in accumulation of muscle lactate leading to early fatigue (Eggers et al., 2001; Fielding & Bean, 1999; Glaser & Davis, 1989; Rogers, 1996).

Glaser, Janssen, Suryaprasad, Gupta, and Methews (1996) have suggested that an active lifestyle incorporating specific exercise training and sports programs is needed to break a debilitating cycle of sedentary existence and to enhance the functional independence and quality of life of individuals with SCI. Hutzler, Ochana, Bolotin, and Kalina (1998) and Dallmeijer, Hopman, Van As, and Van der Woude (1996) stated that active individuals with lower-limb impairments may experience improved function in many typical daily life activities that usually demand anaerobic resources, compared to inactive individuals with the same impairments.

Recently, some studies have investigated the anaerobic power of individuals with quadriplegia (Coutts & Stogryn, 1987; Janssen, Van Oers, Hollander, Veeger, & Van der Woude, 1993; Van der Woude, Bakker, Elkhuizen, Veeger, & Gwinn, 1997) by using a wheelchair ergometer (WCE). These studies reported low values of peak power but the sample sizes used were relatively small (i.e., 2-11 individuals). No scientific evidence was found regarding the anaerobic performance of individuals with quadriplegia, using an arm crank ergometer (ACE) as the mode of exercise. In recent studies, Van der Woude, Veeger, Dallmeijer, Janssen, and Rozendaal (2001) and Janssen, Dallmeijer, Veeger, and Van der Woude (2002) stated that differences in anaerobic power are caused by population variation but are also influenced by the experimental setup (WCE or ACE) and protocol (resistance) used. Results of maximal power outputs during arm cranking (ACE) are higher compared to wheelchair arm work (WCE). In the present study, the arm crank ergometer was used to evaluate anaerobic performance. This method seems to be more available in many laboratories, because of the lower costs and portability of the device (Hutzler, 1998; Shephard, 1990).

The Wingate Anaerobic Test (WAnT) has been accepted in laboratories around the world for assessment of muscle power, muscle endurance, and fatigability (Bouchard et al., 1991). Conceptually, the testing of anaerobic performance of persons with neuromuscular disease is based on principles similar to those used...
in able-bodied populations (Van Praagh, 1998). Jacobs, Mahoney, and Johnson (2003) established reliability \((r = 0.92\) for peak power, \(r = 0.94\) for mean power) and validity of arm cranking for the measurement of anaerobic performance in persons with paraplegia caused by SCI. In the present study, the WAnT protocol was used to evaluate anaerobic performance of both active and sedentary individuals with quadriplegia.

The postexercise blood lactate accumulation is determined following WAnT to provide an indication of the extent to which glycolysis has been stressed. As of this date, no scientific evidence has been found regarding lactate response to anaerobic short intensive exercises as well as optimal timing to detect peak lactate accumulation (L.Apeak) in quadriplegic populations. Peak blood lactate concentration after intense exercise is often used as a measure of anaerobic energy release during muscle contraction (Gastin, 1994). It is postulated that a higher concentration of blood lactate seems to have resulted from an enhanced potential to derive energy via the glycolytic pathway (Granier, Mercier, Anselme, & Prefaut, 1995).

It is well known, however, that many factors may determine peak blood lactate accumulation after intense exercise including participants’ fitness level, muscle fiber composition, and aerobic and phosphagenic contribution in the energy supply during exercise (Weinstein, Bediz, Dofan, & Falk, 1998).

Several investigators have tried to identify the most important determinants of anaerobic capacity in the able-bodied population (Bouchard et al., 1991; Inbar, Bar-Or, & Skinner, 1996) and SCI population (Hutzler, 1993; Hutzler, Grunze, & Kaiser, 1995; Hutzler, 1998; Hutzler et al., 1998; Janssen et al., 2002; Krause & Crewe, 1991). It is well established that anaerobic performance decreases with age in able-bodied persons (Di Prampero & Cerretelli, 1969; Inbar & Bar-Or, 1986; Makrides, Heigenhauser, McCartney, & Jones, 1985). Hutzler (1998) did not confirm such tendency in individuals with lower limb impairments. Krause and Crewe (1991), on the other hand, suggest that physical activity in individuals with SCI tend to be lower in those with a higher chronological age and more recent injury. Coutts and Stogryn (1987), Hutzler et al. (1998), and Janssen et al. (2002) report that lesion level is one of the most limiting factors for an increase of anaerobic capacity in the SCI population. Many studies, however, have attempted to examine the most important determinants of anaerobic performance in the SCI population and have found there has been a lack of study regarding these relationships exclusively in a homogeneous quadriplegic population. Because of the practical applications such as individual fitness assessment, optimal timing of the intervention after the injury, or appropriate training program expectations, it is important to establish the role of physical activity and other demographic information (age, time since injury, body mass, lesion level) on the anaerobic performance of individuals with quadriplegia.

In a review study by Hutzler (1998), no investigations were reported on how anaerobic performance level differs between sedentary and active individuals with quadriplegia. And, no scientific evidence has been found regarding the reference values of power output in this group. Previous studies, which have considered the anaerobic performance of individuals with quadriplegia, have reported no clear findings (Coutts & Stogryn, 1987; Hutzler, 1998; Van der Woude et al., 2001). This is usually explained by problems with the sample used—samples are often small and combine persons with quadriplegia and paraplegia (Coutts & Stogryn, 1987; Hutzler, 1998; Van der Woude et al., 2001).
Therefore, the purpose of this study was to compare anaerobic performance of active and sedentary individuals with quadriplegia and to determine a relationship between anaerobic performance and age, body mass, lesion level, and time since injury in a group of active and sedentary individuals with quadriplegia. It was hypothesized that anaerobic performance would be significantly higher in the active group compared to the sedentary group.

Method

Participants

A group of 31 individuals with quadriplegia took part in this study. All participants recruited for this study were males with traumatic cervical SCI (C5-C7). They were a minimum of one year from the date of accident and used a manual wheelchair. Participants were divided into two groups according to their sport involvement. Both groups participated in basic rehabilitation exercises—usually passive movements of lower limbs performed by physiotherapist or family member (about 30 min per day). The sedentary group consisted of 12 individuals and had not been engaged in any sport for at least one year. The active group composed of 19 athletes (Polish Wheelchair Rugby League players) who were involved in their sport at least twice per week (each session 60 min) for at least one year. The demographic information about participants (age, height, body mass, BMI, and time since injury) is provided in Table 1.

The number of participants per lesion level is presented in Table 2. All participants (except two individuals) had incomplete lesions. Written informed consent was obtained from each participant and the Ethics Committee of Academy of Physical Education in Warsaw approved the study.

Table 1  Demographic Information About Active and Sedentary Individuals With Quadriplegia

<table>
<thead>
<tr>
<th>Variable</th>
<th>Active ($n=19$)</th>
<th>Sedentary ($n=12$)</th>
<th>t value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>31 6</td>
<td>29 9</td>
<td>0.79</td>
<td>0.44</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.80 0.07</td>
<td>1.83 0.07</td>
<td>-1.02</td>
<td>0.32</td>
</tr>
<tr>
<td>Body mass (kg)</td>
<td>72.48 11.13</td>
<td>69.54 10.21</td>
<td>0.74</td>
<td>0.47</td>
</tr>
<tr>
<td>BMI</td>
<td>22.18 3.80</td>
<td>20.86 2.95</td>
<td>1.03</td>
<td>0.31</td>
</tr>
<tr>
<td>Time since injury (years)</td>
<td>11 5</td>
<td>9 7</td>
<td>0.81</td>
<td>0.42</td>
</tr>
</tbody>
</table>

Note. BMI refers to Body Mass Index (kg/m²)
Instrumentation

Body mass was measured with the scale weight type WPT 8.300BC (Radwag, Radom, Poland). Participants were weighed in normal track clothing while sitting in a wheelchair, and the mass of the wheelchair was subtracted from the total recorded mass.

To determine anaerobic power and capacity, the WAnT test procedure (also called anaerobic 30-second arm-all-out test) was used with an arm crank ergometer (ACE) named Angio (Lode, Groningen, the Netherlands). The ergometer was connected online to a personal computer. The WAnT Software Package and interface RS232 (Lode, Groningen, the Netherlands) were used to collect and process data. Four indices were measured during the WAnT: peak power output (PP) defined as the highest 5-s power output, mean power output (MP)—the average power sustained throughout the 30-s period, the lowest power output (LP)—the lowest 5-s power output, and time to achieve PP (t) (Inbar; Bar-Or & Skinner, 1996). The WAnT Software Package also calculated fatigue index (FI) as percentage of decline in power output (FI = PP - LP / PP x 100), relative peak power output (rPP), and relative mean power output (rMP) with respect to body mass.

Heparinized 10 μl capillaries were used to collect blood samples from the earlobe. Lactate concentration (LA) was measured using the Spectrophotometer Technique LP 400 (Dr Lange Company, Dusseldorf, Germany). The accuracy of the analyzer was checked by standard solution in lactate concentration (2, 4 and 10 mmol·l⁻¹). The coefficient of variation for repetitive analyses of the identical samples (4 mmol·l⁻¹ standard solution) was 4.4%.

Testing Procedure

Testing took place between 8:00 a.m. and 1:00 p.m. The participants were asked to refrain from ingesting caffeine, nicotine, and alcohol for at least 5 hours prior to testing and to refrain from meals for at least 1.5 hour prior to testing. Before testing, the participants were examined by a general practitioner. A personal questionnaire was completed to obtain the following data: age, height, date of accident, type of accident, level of lesion, and severity of lesion. Then, the research team measured body mass and calculated body mass index (BMI = kg body mass / height in m²). Participants then performed the Wingate Anaerobic Test (WAnT) with the arm crank ergometer (ACE).

Table 2  Number of Participants per Lesion Level

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>C 5</th>
<th>C 5/6</th>
<th>C 6</th>
<th>C 6/7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active</td>
<td>19</td>
<td>2</td>
<td>7</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Sedentary</td>
<td>12</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Note. Two sedentary participants had complete lesion—one with C6 lesion level and one with C 6/7 lesion level. This may have influenced findings.
The participants sat in the front of the ACE in their own braked wheelchairs held by two research team assistants. The height of the ACE axis was positioned at the level of the participant’s shoulders. The horizontal distance from the ACE was chosen so as to allow for a slight flexion at the elbow at the furthest point of the cranking movement. For participants with severe impairment of hand function, an elastic bandage was used to fix the hands to the handlebars.

The test protocol consisted of a two-minute warm up, cranking at 60 rpm without resistance. The Wingate test resistance equated to 1-2% of body mass. Optimization of the braking force was based on the Force –Velocity Test (Inbar; Bar-Or & Skinner, 1996). The participant cranked as fast as possible and measuring started as soon as 25 rpm was registered by the system. The counting of revolutions lasted exactly 30 s (Lode, 1998). Verbal encouragement was given throughout the test.

The blood samples for lactate determination were taken from the earlobe after the third, fifth, seventh, and ninth minute after the exercise cessation. The blood lactate concentration was measured immediately after blood sample collection using commercial test kits (Dr Lange Company, Dusseldorf, Germany). Briefly, after hemolysis of blood, lactate was oxidized to pyruvate, which formed a red quinonimine red dye with 4-aminophenazone.

Data Analysis

Data were analyzed statistically by using STATISTICA 5.1 package (StatSoft, Poland). The Mann Whitney test was applied to analyze differences in both groups with respect to lesion level (C5 was ranked as 1, C5/6 was ranked as 2, C6 was ranked as 3, C6/7 was ranked as 4). The t-test for independent samples with assumption of unequal variances (except the calculation for PP, MP, and LApeak) was applied to test for differences in anaerobic performance parameters and blood lactate accumulation between the active and sedentary group. The effect size was determined by calculating the Cohen’s $d$ for all statistically significant results. Values of $d > 0.80$, $> 0.50$ and $> 0.20$ were typically considered to represent large, moderate, and small meaningfulness of results, respectively. Spearman rank order correlation coefficients were computed over the total group (active and sedentary together, $n = 31$) between lesion level, time since injury, age, body mass, rPP, rMP, and FI. Significance was set at the $p \leq .05$ level.

Results

No significant differences between the active and sedentary group were found with respect to age, height, body mass, BMI, and time since injury. Using the Mann Whitney test to verify the difference in lesion level between two groups, the results were not significant ($U = 77.5, p = 0.14$).

Comparisons between the two groups (active and sedentary) for anaerobic performance parameters are presented in Table 3. Differences between the two groups for mean power (MP), fatigue index (FI), and peak blood lactate accumulation (LApeak) were found to be significant at $p = .020$, $p = .048$, and $p = .033$, respectively. The relative value of MP with respect to body mass was significant at $p = .018$, while the lowest power (LP) reached a significance of $p = .003$. The effect size ($d$ value) showed a large magnitude of difference between active and
The sedentary group for MP, rMP, LP, and FI while moderate for LApeak. No significant difference was observed for peak power (PP), relative peak power (rPP), and time to achieve PP (t) between the active and sedentary group.

**Table 3** Comparisons of Anaerobic Performance Parameters During WAnT in Active and Sedentary Individuals With Quadriplegia

<table>
<thead>
<tr>
<th>Variable</th>
<th>Active (n = 19)</th>
<th>Sedentary (n = 12)</th>
<th>t value</th>
<th>p value</th>
<th>d value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PP (W)†</td>
<td>149.95 ± 55.10</td>
<td>112.00 ± 81.75</td>
<td>1.55</td>
<td>.066</td>
<td>0.57</td>
</tr>
<tr>
<td>rPP (W·kg⁻¹)</td>
<td>2.08 ± 0.72</td>
<td>1.60 ± 1.09</td>
<td>1.48</td>
<td>.074</td>
<td>0.55</td>
</tr>
<tr>
<td>MP (W)†</td>
<td>112.76 ± 30.19</td>
<td>74.20 ± 54.37</td>
<td>2.25</td>
<td>.020*</td>
<td>0.94</td>
</tr>
<tr>
<td>rMP (W·kg⁻¹)</td>
<td>1.57 ± 0.40</td>
<td>1.06 ± 0.71</td>
<td>2.28</td>
<td>.018*</td>
<td>0.95</td>
</tr>
<tr>
<td>LP (W)</td>
<td>84.63 ± 22.36</td>
<td>43.25 ± 41.24</td>
<td>3.19</td>
<td>.003**</td>
<td>1.34</td>
</tr>
<tr>
<td>t (s)</td>
<td>8.84 ± 2.58</td>
<td>9.90 ± 4.47</td>
<td>-0.75</td>
<td>.233</td>
<td>-0.31</td>
</tr>
<tr>
<td>FI (%)</td>
<td>41.22 ± 10.23</td>
<td>57.93 ± 31.12</td>
<td>-1.80</td>
<td>.048*</td>
<td>-0.8</td>
</tr>
<tr>
<td>LApeak (mmol·l⁻¹)†</td>
<td>5.7 ± 2.3</td>
<td>4.2 ± 1.9</td>
<td>1.89</td>
<td>.033*</td>
<td>0.7</td>
</tr>
</tbody>
</table>

*Note.* † - independent t-tests for PP, MP, and LApeak were calculated with assumption of equal variances. PP refers to peak power, rPP refers to relative peak power, MP refers to mean power, rMP refers to relative mean power, LP refers to the lowest power, t refers to time to achieve PP, FI refers to fatigue index, LApeak refers to peak blood lactate accumulation. *d value represents the effect size. *p < .05. **p < .01.

**Table 4** Comparisons of Postexercise Blood Lactate Responses in Active and Sedentary Individuals With Quadriplegia

<table>
<thead>
<tr>
<th>Lactate (mmol·l⁻¹) after:</th>
<th>Active (n = 19)</th>
<th>Sedentary (n = 12)</th>
<th>t value</th>
<th>p value</th>
<th>d value</th>
</tr>
</thead>
<tbody>
<tr>
<td>3rd min</td>
<td>4.0 ± 1.2</td>
<td>3.6 ± 1.0</td>
<td>1.03</td>
<td>.154</td>
<td>0.38</td>
</tr>
<tr>
<td>5th min</td>
<td>5.5 ± 2.1</td>
<td>4.1 ± 1.8</td>
<td>1.93</td>
<td>.032*</td>
<td>0.70</td>
</tr>
<tr>
<td>7th min</td>
<td>5.6 ± 2.3</td>
<td>4.1 ± 2.0</td>
<td>1.91</td>
<td>.033*</td>
<td>0.68</td>
</tr>
<tr>
<td>9th min</td>
<td>5.3 ± 2.2</td>
<td>4.0 ± 2.2</td>
<td>1.59</td>
<td>.061</td>
<td>0.59</td>
</tr>
</tbody>
</table>

*Note.* d value represents the effect size. *p < .05.
Postexercise mean blood lactate accumulation in fifth and seventh minutes after WAnT was significantly higher in the active than in the sedentary group (Table 4). The magnitude of difference was moderate ($d > 0.5$). In the active group, LApeak was established in seventh minute after cessation of the exercise. In the sedentary group, mean blood lactate accumulation was the same in fifth and seventh minutes after WAnT.

The Spearman rank order correlation coefficient between demographic and anaerobic performance variables within the whole group of individuals with quadriplegia (Table 5) showed a significant relationship between rMP and injury lesion level ($r = .43, p = .016$). A significant correlation was also observed between rPP and rMP ($r = .93, p = .000$).

### Table 5  Spearman Rank Order Correlation Matrix Between Demographic and Anaerobic Performance Variables in Individuals With Quadriplegia

<table>
<thead>
<tr>
<th></th>
<th>Body mass</th>
<th>Time since injury</th>
<th>Age</th>
<th>rPP</th>
<th>rMP</th>
<th>FI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lesion level</td>
<td>.03</td>
<td>.30</td>
<td>.30</td>
<td>.31</td>
<td>.43*</td>
<td>-.19</td>
</tr>
<tr>
<td>Body mass</td>
<td>.13</td>
<td>.23</td>
<td>-.11</td>
<td>-.15</td>
<td>-.06</td>
<td></td>
</tr>
<tr>
<td>Time since injury</td>
<td>.78</td>
<td>.21</td>
<td>.19</td>
<td>-.11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>.09</td>
<td>.11</td>
<td></td>
<td></td>
<td></td>
<td>-.23</td>
</tr>
<tr>
<td>rPP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.93***</td>
<td>.28</td>
</tr>
<tr>
<td>rMP</td>
<td></td>
<td></td>
<td></td>
<td>.06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. rPP refers to relative peak power, rMP refers to relative mean power, FI refers to fatigue index. * $p < .05$. *** $p < .0001$.*

### Discussion

The major finding of this study is that MP, rMP, LP, FI, and LApeak in the active group were significantly higher than those of the sedentary group. Surprisingly, the peak power and relative peak power were not significantly different between the active and sedentary group. It should be noted that systematic physical activity in the form of wheelchair rugby—a team game that can be adapted to a wide range of individual abilities (Bromley, 1998; Sherrill, 1998; Yilla & Sherill, 1998) and combines short intense sessions of exercise over an extended playing time—can improve aerobic as well as anaerobic capabilities (Coutts, Reaburn, & Abt, 2003). The higher LApeak in active, compared to sedentary individuals with quadriplegia, is probably an effect of the higher muscle power in this group. It cannot be excluded that it is also a result of alteration induced by training that led to an increase glycolysis activation in muscles and enzyme activity of the anaerobic lactate pathways (Rodas, 2000). One of the possible mechanisms for improved MP, rMP, LP, and FI is an increase in skeletal muscle buffering capacity (Weston,
Anaerobic Performance in Quadriplegia

Myburgh, & Lindsay, 1997). It is well established that lactate clearance is improved by sport training (Mac Rae, Dennis, Bosch, & Noakes, 1992). Apparently, the training stimulus was insufficient to increase muscle phosphocreatine, an energy system that determines muscle power (Rodas, Ventura, Cadefau, Cusso, & Parra, 2000). The lack of significant differences in PP and rPP between the two groups may also be related to the variability among scores of the mentioned parameters in the sedentary group (Table 3). It may be concluded, therefore, that in terms of muscle endurance (MP) and fatigability (FI), the anaerobic performance of active individuals is higher than in sedentary individuals with quadriplegia.

Findings of previous studies concerning anaerobic performance of individuals with quadriplegia are inconsistent. It was established that values of PP achieved through WCE in individuals with quadriplegia were from 41.0 W to 16.0 W (Coutts & Stogryn, 1987; Janssen et al., 1993; Van der Woude et al., 1997), while in our study, values of PP achieved through ACE in both active and sedentary individuals with quadriplegia were surprisingly higher (150.0 W, 112.0 W, respectively). This suggests that although both tests (WCE and ACE) are performed by the upper limbs, the structure of the movement considerably influences the achieved values of PP.

In the present study, values of PP in active individuals with quadriplegia (150.0 W) are lower than values of PP in athletes with high and low paraplegia (325.0 W, 394.0 W, respectively). This was also reported by Hutzler et al. (1998) with a similar approach (WAnT and ACE). The results of this study support those of Coutts & Stogryn (1987) in that athletes with paraplegia display higher scores of anaerobic performance than do quadriplegic athletes.

The relationship between rPP and rMP in the whole group was high (r = .93, p = .000). These results are in accordance with Hutzler’s (1995) conclusions based on the study of the physiological response of wheelchair basketball players to the WAnT test using a WCE. Although it suggests that one of these indices would be sufficient to estimate anaerobic performance, it is recommended that both indices be reported (Hutzler, 1998).

The moderate but significant correlation between lesion level and relative mean power (r = .43, p = .016) established in this study confirmed the previous assumption that anaerobic performance of individuals with SCI depends on lesion level (Coutts & Stogryn, 1987; Hutzler, 1998; Jansen et al., 2002). In an earlier study with a similar experimental setup (ACE and WAnT), Hutzler (1993) reported the relationship between muscle endurance (MP) and functional classification (r = .717, p = .015) and body mass (r = .817, p = .004) in wheelchair basketball players. A lack of correlation in the present study among other demographic and anaerobic performance variables in active and sedentary individuals with quadriplegia may be explained by the absence of participants with a low lesion level (C7, C7/8) or those with a complete lesion. Future research should include participants with a wider variety of lesion levels and severity of lesion (complete/incomplete). This will allow for a more detailed investigation of the relationship between demographic and anaerobic performance parameters.

An estimation of anaerobic energy yield can be derived from the test results and also supplemented by biochemical measurements such as blood lactate (Bouchard et al., 1991). Measurement of blood lactate after intense exercise has frequently been used and provides an indicator of the extent of anaerobic glycolysis; however, it cannot be used as a qualitative measure of anaerobic energy yield (Gastin, 1994). Lactate production, distribution, and removal play equally important
roles in blood lactate concentration. Removal and elimination of lactate was facilitated by protein carriers (MCTs) linked to the sarco-plasmatic membrane, and it was found that training status could affect the concentration of MCTs (Billat, Sirvent, Py, Koralsztein, & Mercier, 2003). In the present study, the tendency to achieve the highest mean values of LA in the fifth and seventh minutes were observed in both groups of individuals with quadriplegia. It seems that the difference in LA Peak between both groups caused higher mean power during W AnT in active persons.

In summary, the results of this study show that, in general, active male individuals with quadriplegia present higher anaerobic performance in terms of muscle endurance and fatigueability compared to sedentary male individuals with quadriplegia. This supports the belief that an active lifestyle enhances the functional potential for independence in everyday tasks. Such tasks include entering and exiting a vehicle, climbing a curb, ascending a ramp, transferring into bed, toilet, or chair and are often difficult to perform for individuals with quadriplegia. It can be concluded that individuals with quadriplegia who are regularly involved in wheelchair rugby may experience improved function during many typical daily life activities that demand anaerobic resources. Future study should investigate why an active lifestyle (participation in wheelchair sport activity) improves only muscle endurance and fatigueability, but not muscle power.

References


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