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Determinants of the prevalence and location of musculoskeletal pain in elite Para athletes

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Abstract

The tendency for musculoskeletal complaints, injuries, and traumas remains significant among Para athletes. The aim of the study was to identify and verify the variables that impact the incidence and location of musculoskeletal pain in elite athletes with disabilities. It was assumed, that the type of disability and not the type of sport, or the type of injuries and traumas is the crucial determinant of the prevalence and location of musculoskeletal pain in Para athletes. A direct-participatory observation method was used in the study including both subjective (surveys questionnaires) and objective (anthropometric) methods of assessment. The study included 35 male and female elite Para athletes from the Polish national team (sitting volleyball [SG1: n = 21], para swimming [SG2 = 14]). Both groups of Para athletes mostly reported pain in the neck (37%), and the lower back (34%). The Spearman's rank-order correlation showed several large inversely proportional relationships between somatic parameters and the values in the Nordic Musculoskeletal Questionnaire from the last 7 days (NMQ-7) for SG2 and some moderate to large correlations between body adiposity index (BAI) and the prevalence of injuries, the total number of rehabilitation sessions, the number of humeral joint and fingers rehabilitation sessions, breaks from training over 4 weeks in SG1. In both groups relationships were found between the duration of Paralympic training and the number of injuries and rehabilitation sessions (R = –0.4; $P < .02$) and between the exclusion from training for less 4 and over 4 weeks (R = –0.4; $P < .03$). The age of the Para athletes correlated with the NMQ-7 (wrists) (R = 0.4; $P < .01$). Both duration of disability and the type and severity of the disability may be crucial determinants of the prevalence and location of pain in the musculoskeletal system in Para athletes. Sport-specific training seems to induce specific musculoskeletal complaints.

Abbreviations: BAI = body adiposity index, BH = body height, BM = body mass, HC = hip circumference, NMQ-7 = the Nordic Musculoskeletal Questionnaire for the last 7 days, WC = waist circumference.

Keywords: injury, low back pain, lower limb amputation, shoulder pain, Sports For Persons with Disabilites

1. Introduction

Sports performance depends on a number of underlying factors,[1] including optimal selection of athletes based on athletic and psychophysical predispositions, nutrition, muscle strength, sleep, recovery, and injury prevention.[1–6] However, sports training is known to be a core aspect of performance enhancement,[7] thus coaches adopt a variety of approaches to place greater training loads on the athlete.[8] Training load acts as a stressor that induces a specific response in the athlete's body to overcome the load, adapt, and enhance performance by increasing the physiological capacity.[9,10] Nevertheless, too high load may cause maladaptation reduce athletic performance and heightening the risk of injury.[11] As has been demonstrated in several studies,[12–15] the type of sport, athlete's physical parameters, individual genetic predispositions, and body's compensatory mechanisms may impact the type of injuries, traumas, and musculoskeletal complaints.

The analysis of the available scientific literature indicates that coaches are seeking new ways and solutions that could enhance sports performance of Para athletes,[16–20] nevertheless the overall rates of injuries in Para athletes are high and comparable with the rates observed in able-bodied athletes.[14,16,17] Additionally, compared to able-bodied athletes, the observed trend leads to more severe consequences as it affects both sports participation and activities of daily living.[16,21] Moreover, there is still no consensus on its etiopathogenesis as it's difficult to indicate the optimal borderline between sport as a form of improving the health of Para athletes and sport as a factor that aggravates the disability.[22] The investigations performed with able-bodied athletes suggest that sport-related movements and extrinsic compensatory mechanisms (body's adaptation and compensation to sports training) are the main determinants of the prevalence and location of injuries, traumas, and musculoskeletal complaints that increase with age, sports performance, and training load.[23,24] However, in regard to Para athletes, this is difficult to confirm because of the compensatory mechanisms.[15,25] According to Gaweł et al[15] and Zwierzchowska et al[25,26] both intrinsic (disability) and extrinsic (sports training) compensations can intensify the vulnerability and prevalence of injuries and musculoskeletal complaints.

The authors have no conflicts of interest to disclose.

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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The data on the frequency and severity of musculoskeletal pain, injuries, and traumas in athletes with disabilities are very limited. The scientific research allows for the identification of its epidemiology to some extent but at the same time, it indicates the need for further and deeper analysis.[16,17,26,27] Given the above and the gap in the available scientific literature, it seems reasonable to search for determinants of the effectiveness of sports training and athletic performance of Para athletes. Accordingly, the aim of the study was to identify and verify the variables that impact the incidence and location of musculoskeletal pain in elite athletes with disabilities. As the preliminary research conducted by the authors of the present study indicated a significant relationship between the type of disability and musculoskeletal complaints[15,26] it was assumed, that the type of disability and not the type of sport, or the type of injuries and traumas is the crucial determinant of the prevalence and location of musculoskeletal pain in Para athletes.

2. Methodology

A direct-participatory observation method was used in the study including both subjective (surveys questionnaires) and objective (anthropometric) methods of assessment.

3. Subjects

In order to identify the determinants of musculoskeletal pain a primary discriminative criteria were established as follows: training environment (terrestrial/aquatic environment), sport-specific position (isolated/elongated). Thereafter 2 sports were selected for further analyses that is: sitting volleyball (SG1) and para swimming (SG2). The inclusion criteria were: at least a minimal disability according to the World ParaVolley or World Para Swimming classification, at least 2 years of training at an elite level, Para athletes (≥14 years), training load located dominantly in the upper limbs. The exclusion criteria were: participant's rejection from taking part in the examinations during the study, lack of central training in the last year. Finally, the study included 35 male and female elite Para athletes from the Polish national team (SG1: n = 21, SG2 = 14) who performed the same training cycle in each of the analyzed sports (preseason mesocycle). Table 1 provides a detailed description of the study participants.

As limb deficiency was reported in the majority of participants, a standard body mass (BM) index formula (BM [kg]/body height [BH]^2 [cm]) could not be used, and thus body adiposity index (BAI) calculated by the formula (BAI = hip circumference [HC] [cm]/(BH [m]) was used instead to estimate body fat among study participants. BAI is known as an objective marker of body adiposity in both able-bodied and disabled populations.[28]

Sitting volleyball players used prostheses (n = 14), orthopedic crutches (n = 3), wheelchairs (n = 1), or no supporting equipment (n = 3) in the activities of daily living and locomotion, whereas most para swimmers did not use any supporting equipment (n = 8). Some athletes from the para swimming group used prostheses (n = 1), wheelchairs (n = 1), and walking frames (n = 1), while white stick was used by blind para swimmers (n = 2).

The study participants were informed about the advantages and disadvantages of the study before providing their written informed consent for participation. The research protocol was approved by the Bioethics Committee for Scientific Research at the Academy of Physical Education in Katowice (No. 9/2012) and met the ethical standards of the Declaration of Helsinki, 2013. Additionally, the participants were allowed to withdraw from the study at any moment.

3.1. Anthropometric measurements

The participants arrived at the Laboratory of Adapted Physical Activity (Institute of Sport Sciences—Academy of Physical Education in Katowice) in the morning (8–11 AM). The procedure was similar as in the preliminary study.[15] A wall-mounted stadiometer with a centimeter scale was used to assess the BH of participants, including the wheelchair users who were able to stand for a short time without additional supporting equipment. A chair weight was used to evaluate BM. HC and waist circumference (WC) were assessed with the use of an anthropometric tape on bare skin, in a lying position and according to the recommended anthropometric techniques, that is, HC – around the greatest convexity of the gluteal muscles below the iliac ala, WC – at the midpoint between the superior iliac crest and the lowest rib.[21] Fat mass was evaluated with a Tanita Viscan AB-140 Abdominal Fat Analyzer with 95% sensitivity and reliability, known to be a golden standard for individuals who cannot stand in the upright position such, for example, amputees.[21]

3.2. The assessment of the prevalence of musculoskeletal pain, injuries, and traumas

The current prevalence and location of musculoskeletal pain in Para athletes was assessed using a standard procedure, similar as in the preliminary study[15] based on the Nordic Musculoskeletal Questionnaire for the last 7 days (NMQ-7).[29] NMQ is known to provide useful and reliable data on musculoskeletal pain as the questionnaire has been tested for validity and reliability.[29] Test validity was verified by comparison of the results obtained for the same participants and they showed almost always identical answers (range of 80%–100%). Similar results were found for the reliability test (range of 78%–100%). The NMQ-7

Table 1

Characteristics of the study participants.

	Total (n = 35; nF = 10, nM = 25)	Sitting volleyball (n = 21; nF = 6, nM = 15)	Para swimming (n = 14; nF = 4, nM = 10)	*P* value
Participant's characteristics		Mean ± SD		
Age (yrs)	28.9 ± 9.3	34.1 ± 7.5	21.0 ± 5.0	**.00003**
Body mass (kg)*	72.6 ± 15.6	77.9 ± 16.0	64.4 ± 9.5	**.009**
Body height (m)	1.74 ± 0.2*	178.6 ± 0.1*	1.73 ± 0.1	.28
Hip circumference (cm)	99.3 ± 10.0	103.3 ± 10.0	93.2 ± 5.6	**.0009**
Waist circumference (cm)	84.4 ± 11.6	89.3 ± 11.1	77.1 ± 7.3	**.002**
BAI (%)	24.2 ± 3.8	24.8 ± 3.8	23.3 ± 3.6	.14
Duration of paralympic sport-specific training (yrs)	8.9 ± 6.6	8.1 ± 7.6	9.9 ± 4.0	.13
Duration of in disability (yrs)	20.2 ± 9.4	20.2 ± 11.1	20.3 ± 5.3	.93
Disability classification		Percentage (%)		
Blinds (%)	14%	0%	36%	-
Amputees (%)	46%	62%	21%	-
Les Autres (%)	34%	38%	29%	-
Cerebral palsy (%)	6%	0%	14%	-

BAI = body adiposity index, n = total number of participants, nF = number of females, nM = number of males, SD = standard deviation.
*Excluded bilateral amputation (n = 1), bold = statistical significance.

concerns the following 9 body parts: the neck, shoulders, upper back, elbows, wrists, lower back, hips/thighs, knees, and ankles/feet. Before completing the questionnaire, study participants were instructed not to report phantom pain because of psychological factors that frequently contribute to this phenomenon.[30] The prevalence and location of injuries and the types of traumas were evaluated by a survey questionnaire developed by Zwierzchowska et al[14] that included the following 3 sections: respondent data and information related to practicing Paralympic sport, (I) the prevalence of injuries, (II) the prevalence of traumas (III). Section II and III concerned the following variables: frequency, location, pain duration, frequency of rehabilitation, its form and duration, duration of the exclusion from the training process because of an injury (section II) or trauma (section III).

4. Statistical Analysis

The distribution of quantitative variables was verified (age, BM, BH, HC, WC, BAI, duration of Paralympic sport-specific training, duration of disability) with Shapiro–Wilk test, that was used because of the small number of the studied participants. Mean values and standard deviations of quantitative variables were computed for all participants and both sports (sitting volleyball/para-swimming) and theirs variety have been verified with Mann–Whitney *U* test (due to small and unequal studied groups). The percentages of participants reporting pain in individual body parts (NMQ-7) and those reporting injuries and trauma in each location were calculated. Relationships between variables (Spearman's correlation) and their differentiation by sport practiced (Mann–Whitney *U* test, chi-squared test) were verified. Correlations were evaluated as follows: trivial (0.0–0.09), small (0.10–0.29), moderate (0.30–0.49), large (0.50–0.69), very large (0.70–0.89), nearly perfect (0.90–0.99), and perfect (1.0). The level of significance for the correlation was set at $P < .05$.

5. Results

Table 2 presents the subjective results of the prevalence and locations of musculoskeletal pain based on the NMQ-7, whereas the incidence, type, and location of the injuries and trauma based on subjective survey questionnaire are shown in Table 3.

Table 2

The prevalence (%) and locations of musculoskeletal pain based on NMQ-7.

	(n = %)			
Body parts (NMQ-7)	Total (n = 35; nF = 10; nM = 25)	Sitting volleyball (n = 21; nF = 6, nM = 15)	Para-swimming (n = 14; nF = 4, nM = 10)	P value
Neck	37%	43%	29%	.39
Shoulders	23%	19%	29%	.51
Upper back	29%	38%	14%	.12
Elbows	14%	19%	7%	.30
Wrists	14%	24%	0%	**.017**
Low back	34%	43%	21%	.18
Hips/ties	23%	24%	21%	.87
Knees*	26%	29%	21%	.63
Ankles/feets*	20%	19%	21%	.86

n = total number of participants, nF = number of females, nM = number of males, NMQ-7 = Nordic Musculoskeletal Questionnaire for last 7 days, SD = standard deviation.
*One participant did not respond due to bilateral amputation above the knees, bold—statistical significance.

Neck (43%), the lower back (43%), and the upper back (38%) were the most frequently reported painful areas in sitting volleyball players, whereas almost similar prevalence of the musculoskeletal pain was noted in para swimmers, that is, neck and shoulders (29%), the lower back and lower limbs (21%) (Table 2). Both groups of Para athletes mostly reported pain in the neck (37%), and the lower back (34%).

Almost similar prevalence of injuries was found in both groups. However, para swimmers were excluded more frequently from the training process, mostly for over 4 weeks. The majority of the reported injuries needed rehabilitation to restore the function of the injured joint (especially humeral joint) and return to sports activity. The highest prevalence of injured joints in sitting volleyball players was reported for the upper limbs, whereas among para swimmers, the lower limbs and shoulders were the most frequently injured areas.

Fewer athletes had traumas, but their total incidence was much higher than the prevalence of injuries in both groups. The most frequent types of traumas among sitting volleyball players and para swimmers were scrapes (388) and bruises (240).

The Spearman's rank-order correlation (Table 4) showed several large negative relationships between somatic parameters and the values in the NMQ-7 (knees, lower back, hips/ties) for para-swimmers. Moreover, some moderate to large negative correlations between BAI and the prevalence of injuries, the total number of rehabilitation sessions, the number of humeral joint and fingers rehabilitation sessions, and breaks from training over 4 weeks were found among sitting volleyball players.

In both groups of Para athletes several moderate positive relationships were found between the duration of Paralympic training and the number of injuries and rehabilitation sessions ($R = –0.4$; $P < .02$) and between the exclusion from training for less than 4 and over 4 weeks ($R = –0.4$; $P < .03$). Furthermore, a moderate positive relationship was found between the age of the Para athletes and NMQ-7 (wrists) ($R = 0.4$; $P < .01$).

6. Discussion

The aim of the study was to identify and verify the variables that influence the prevalence and location of musculoskeletal pain in elite Para athletes. Although numerous injuries and traumas were reported, the statistical analysis did not show any significant relationships with musculoskeletal complaints neither in both groups nor individually (sitting volleyball and para swimming). Moreover, the results of the present study showed that participation in sport-specific training may lead to musculoskeletal complaints; however, the type of disability and its duration seem to be the major determinants of the prevalence and location of musculoskeletal pain in athletes with disabilities. This is in agreement with our previous research[15] that suggested both intrinsic and extrinsic compensatory mechanisms as the main factors affecting body posture and inducing musculoskeletal pain in Para athletes. Similar relationships were confirmed in able-bodied athletes by a meta-analysis conducted by Zwierzchowska et al.[31]

Considering the issue of body's external compensatory mechanisms our study did not find significant relationships between NMQ-7 and sport-specific training. However, the results indicate that the location of musculoskeletal complaints is associated with the sport practiced. At the same time, the reported location and type of injuries and traumas seem to be type-specific to each group of Para athletes studied. Pain in the upper limbs and upper and lower back was mostly reported in sitting volleyball players, which is typical of athletes of overhead sports and those with forced sitting position.[15,32] As indicated by Ahmadi et al[33] sitting volleyball players tend to continuously overload shoulder girdle

Table 3

The prevalence and locations of injuries and the prevalence and types of trauma based on the subjective questionnaire.

	Number (n) or percentage (%)			
	Total (n = 35; nF = 10; nM = 25)	Sitting volleyball (n = 21; nF = 6, nM = 15)	Para swimming (n = 14; nF = 4, nM = 10)	*P* value
INJURIES (n = 54)				
Number of para athletes that reported an injury	n = 18 (51%)	n = 11 (52%)	n = 7 (50%)	.89
Number of para athletes reported injury exclusion from trainings	n = 10 (32%)	n = 2 (7%)	n = 8 (26%)	.51
Number of para athletes that reported break from trainings <4 wks	n = 6 (17%)	n = 3 (14%)	n = 3 (21%)	.58
Number of para athletes that reported break from trainings >4 wks	n = 4 (11%)	n = 2 (7%)	n = 2 (14%)	.66
Number of para athletes that reported injuries that needed surgical treatment	n = 3 (9%)	n = 1 (5%)	n = 2 (14%)	.32
Humeral joint	2	1	1	.80
Knee joint	1	0	1	.18
Number of para athletes reported injuries that needed rehabilitation	n = 13 (37%)	n = 7 (33%)	n = 6 (43%)	.56
Humeral joint	18	9	9	.82
Shoulder	8	2	6	.64
Wrist joint	7	6	1	.89
Knee joint	5	2	3	.94
Foot	5	1	4	.63
Elbow joint	4	3	1	.93
Fingers	4	4	0	.49
Hand	1	0	1	.74
Pelvis	1	1	0	.83
Spine	1	1	0	.83
TRAUMAS (n = 665)				
Number of para athletes that reported a trauma	n = 15 (43%)	n = 10 (48%)	n = 5 (36%)	.48
Types of traumas				
Scrape	388	83	305	.65
Bruise	240	88	152	.41
Tissue strain	17	9	8	.45
Joint dislocation	8	3	5	.95
Sprain	7	1	6	.64
Bone fracture	5	0	5	.49

n = number of study participants, nF/nM = number of females/males.

Table 4

Spearman's rank-order correlation between the measured data in the groups of sitting volleyball players and para swimmers.

Sitting volleyball (n = 21)		Para-swimming (n = 14)	
Correlation	The level of significance	Correlation	The level of significance
The number of breaks from training <4 wks & BAI	R = (−0.5); *P* < .03	Duration of disability & the number of breaks from training <4 wks	R = (−0.6); *P* < .04
The number of injuries & BAI	R = (−0.5); *P* < .01	NMQ-7 (shoulders) & Duration of disability	R = (−0.6); *P* < .01
The number of rehabilitation sessions & BAI	R = (−0.5); *P* < .01	NMQ-7 (knees) & BM	R = (−0.5); *P* < .05
The number of humeral joint rehabilitation sessions & BAI	R = (−0.4); *P* < .4	NMQ-7 (knees) & BH	R = (−0.5); *P* < .05
The number of fingers rehabilitation sessions & BAI	R = (−0.5); *P* < .03	NMQ-7 (knees) & HC	R = (−0.6); *P* < .03
		NMQ-7 (lower back) & WC	R = (−0.6); *P* < .01
		NMQ-7 (hips/ties) & WC	R = (−0.6); *P* < .01

BAI = body adiposity index, BH = body height, BM = body mass, HC/WC = hips/waist circumference, n = total number of study participants, NMQ-7 = The Nordic Musculoskeletal Questionnaire for last 7 days.

during playing, which contributes to asymmetrical rotational strength profile. This is commonly observed in this group of Para athletes and seems to be associated with activation of extrinsic compensatory mechanisms. On the other hand para swimmers complained mostly about the pain in both upper and lower limbs and lower back, which is consistent with the findings of other authors that have examined the prevalence of pain among able-bodied swimmers.[34,35] Although swimming has been considered a form of prevention and correction of spinal curvatures disturbances and a comprehensive sport,[36] several studies have contradicted this approach and indicated that training load combined with sport-specific movements increase the risk of injuries, traumas, postural disturbances, and musculoskeletal complaints in able-bodied athletes.[15,37,38] Such findings confirm the effect of the body's extrinsic compensation. As our findings showed several large negative correlations between somatic parameters and NMQ-7 in para swimmers there is a reason to believe that the individual characteristics of the athlete and not the type of sport can be a determining factor in inducing musculoskeletal pain due to the body's intrinsic compensation.

Although the previous studies have shown the directly proportional relationship between intrinsic compensation and the prevalence and location of musculoskeletal pain in elite Para athletes[15,26] the impact of participants' age and duration of disability was not confirmed. As indicated by Zwierzchowska et al,[26] the body's intrinsic compensation could result in wrist pain in sitting volleyball players (athletes with lower limb deficiency). This is consistent with our findings of a directly proportional relationship between athletes' age and the NMQ-7 in wrists. Furthermore, the present study showed several inversely proportional correlations between sport-specific training experience and the prevalence of injuries, rehabilitation sessions, and exclusion from training for less and over 4 weeks in both groups. Taking this into account, it can be postulated that duration of Paralympic training may be a significant variable to predict the prevalence of injuries and musculoskeletal complaints among Para athletes, which was especially noticeable in the group of sitting volleyball players that included older study participants. It was found that in the progressive period of disability the number of injuries and the prevalence of pain in the athlete's musculoskeletal system were higher. This leads to the conclusion that sport-specific training induces musculoskeletal pain. However, the type and severity of disability seem to be a significant determinant of musculoskeletal complaints in elite Para athletes.

7. Limitations

Our study is not without limitations. We have investigated and compared only 2 different Para lympic sports, with groups of athletes characterized by various somatic para meters, age, diverse disabilities (sitting volleyball, para-swimming), gender, and the number of athletes (sitting volleyball: n = 21; para swimming: n = 14). However, the study participants were elite Para athletes (the entire men's and women's Polish national team) and therefore the study groups were not large. It should also be acknowledged that there are few Para athletes at an elite level that could be included in the study. Besides, the Para athletes studied were characterized by a similar mean duration of both disability and Paralympic training and the gender variable was not significant in the statistical analysis for the verification of the study aim and hypothesis. Nevertheless, future studies should be extended to include more Para athletes from various Paralympic sports to enable generalization.

8. Conclusions

In conclusion, the present study provides novel insights into the monitoring of the training process of athletes with disabilities as it indicates the importance of compensatory mechanisms and provides important data on the determinants of the prevalence and location of musculoskeletal pain. Based on the main findings of this study, it can be concluded that both duration of disability and the type and severity of the disability may be crucial determinants of the prevalence and location of pain in the musculoskeletal system in Para athletes. However, sport-specific training seems to induce sport-specific musculoskeletal complaints. In this light, coaches and athletes are advised to include adaptive proprioceptive exercises in training programs for Para athletes to decrease the negative effects of intrinsic and extrinsic compensation.

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