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PREVALENCE OF GENERALISED JOINT HYPERMOBILITY IN RELATION TO SELECTED MEDICAL AND TRAINING INDICATORS IN SWIMMERS: RANDOMISED CONTROL STUDY

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Abstract

Generalised joint hypermobility (GJH) is characterised by the range of motion that exceeds normal limits in multiple joints. GJH is relatively common. When it is accompanied with other manifestations, it is defined as a health-related disorder, like Joint Hypermobility Syndrome (JHS) or the Ehlers–Danlos Syndrome - Hypermobile Type (hEDS). The prevalence of GJH is higher in sporting than in the general population. The aim of the study was to investigate the prevalence of GJH in competitive swimmers and its relation to the number and type of injuries, pain and selected anthropological and training indicators. The research group consisted of 97 competitive Polish swimmers (50 males; 47 females) aged 15-24 years. Body stature and body mass was measured. Participants completed a questionnaire to collect demographic data and information on previous injuries. Concerning joint hypermobility, participants were examined with the Beighton Scale. Spearman's rank correlation test was applied for analysis. GJH is an often-occurring symptom among the researched group. There was no correlation between selected acute injuries nor chronic pain and GJH in the study group. Several other correlations were noted.

***Keywords*:** Generalised joint hypermobility; Swimmers; Pain; Injuries.

INTRODUCTION

Joint Hypermobility (JH) is the term to define the capability that a joint has to move, passively and/or actively, beyond normal limits along physiological axes. When JH is observed at one or a few types of joints (usually fewer than five) it may be defined as Localised Joint Hypermobility (LJH), while Generalised Joint Hypermobility (GJH) is used when JH affects multiple joints simultaneously (Castori *et al*., 2017).

Prevalence of GJH varies according to age, gender and ethnicity (Clinch *et al*., 2011; Du Toit *et al*., 2011; Sohrbeck-Nøhr *et al*., 2014). For example, in the United States its prevalence

is reported from 4.9% to 23.9%, with higher rates seen among adolescent, children and women (Russek *et al*., 2016). This variability makes the comparison of outcomes of different research findings problematic. GJH can be observed in healthy individuals, in absence of musculoskeletal pain or rheumatologic disease. According to Simpson (2006), GJH not associated with systemic disease, occurs in 4% to 13% of the population and is more common in females. When GJH is accompanied by other symptoms, it is defined as a health-related disorder, for example, Joint Hypermobility Syndrome (JHS) or the Hypermobile EDS (hEDS) (Konopiński *et al*., 2012; Scheper *et al*., 2013; Russek *et al*., 2016; Juul-Kristensen *et al*., 2017; Malfait *et al*., 2017).

According to research, the prevalence of GJH is higher in sporting than in general populations and it varies among different sport disciplines (Soper *et al*., 2015). GJH is most common in ballet dancers (even 97%) (Day *et al*., 2011) and other athletes who require hypermobility, like gymnasts (Soper *et al*., 2015). There are several studies that investigated the prevalence of GJH in other sport disciplines, such as rugby (Stewart & Burden, 2004), netball (Soper *et al*., 2015), football (Collinge & Simmonds, 2009) and lacrosse (Decoster *et al*., 1999). To the best of our knowledge, in the current literature reviewed there is an absence of research describing the prevalence of GJH in competitive adult swimmers.

Swimming is a discipline that requires much effort and time for practising. Training sessions of swimmers are composed of different types of exercises in water and on land to increase strength, endurance, coordination and flexibility (Wright & Copland, 2004; Taormina, 2014). The latter skill is essential for swimmers to achieve a correct swimming technique in one of four styles (breaststroke, backstroke, freestyle, butterfly stroke). Increased range of motion of joints is necessary to perform the technique of strokes effectively, especially the range of motion of the shoulder girdle, hips and ankle. This is essential to minimise resistance of the water and increase the efficiency of the movements (Rakowski, 2008). Range of motion that exceeds physiological limits is a risk factor for injuries like sprains, dislocations (or even fractures) and is often related to chronic pain (Loudon *et al*., 1998; Bin Abd Razak *et al*., 2014; Castori *et al*., 2017; Malfait *et al*., 2017). According to the literature searched, the most common injury among competitive swimmers is the injury of the shoulder (Bales & Bales, 2012). The knee is the second-most-reported source of pain for competitive swimmers (Wanivenhaus *et al*., 2012).

Generalised Joint Hypermobility is strongly related to joint pain. According to Sohrbeck-Nøhr *et al*. (2014), children with GJH had three times higher risk of developing joint pain in adolescence. The aetiology of the joint pain in hypermobile individuals remains idiopathic (Sohrbeck-Nøhr *et al*., 2014).

PURPOSE OF RESEARCH

The aim of the study was to investigate the prevalence of GJH in competitive swimmers and its relation to the number of selected acute injuries and chronic pain and selected anthropological and training indicators. The choice was made to investigate a number of sprains and dislocation and chronic pain because of its relation to GJH (Castori *et al*., 2017; Malfait *et al*., 2017). Additionally, fractures were also examined.

METHODOLOGY

Participants

Ninety-seven (n=97) competitive Polish swimmers (50 males and 47 females) were randomly selected from the participants of Grand Prix of Poland in swimming. Inclusion criteria were: a minimum of four years of competitive swimming experience, practise more than seven times a week (one training unit lasts at least 1.5 hour).

Table 1. CHARACTERISTICS OF SWIMMERS ACCORDING TO GENDER

Variables	Males (n=50) M±SD	Range	Females (n=47) M±SD	Range	Total group (n=97) M±SD	Range
Age (yrs)	17.00±1.654	15-22	17.36±2.570	15-24	17.18±2.146	15-24
Body mass (kg)	73.50±8.074	52-89	61.57±7.768	47-88	67.54±9.903	47-89
Body stature (cm)	182.10±6.877	162-194	171.00±6.967	158-188	176.53±8.860	158-194

Procedures and ethical consideration

During the examination swimmers were barefoot and dressed in swimming suits. All measures were taken in the morning, before the competition. Body stature was measured with the use of Martin's type anthropometer, with an accuracy of 0.1 cm. Measures were taken while standing, arms hanging freely. Body mass was measured with the use of electronic scale (Tanita DC-430 S MA) with the accuracy of 0.1kg. To collect demographic data and information regarding previous injuries, participants completed a questionnaire. The purpose was also to establish age, gender and years of training experience.

Table 2. **BEIGHTON SCALE CRITERION**

Test	Criteria	Right	Left
Fifth finger extension	Passive extension >90º	1	1
Wrist flexion thumb abduction	Passively abduct the thumb to oppose the flexor aspect of forearm	1	1
Elbow extension	Hyperextension >10º	1	1
Trunk and hip flexion	Knees fully extended, forward flexion of the trunk, able to place the flat hand on the floor	1	
Knee extension	Hyperextension >10º	1	1
	Total	9	

To collect data regarding joint hypermobility, the swimmers were examined with the Beighton Scale (Table 2) that is the most recognised tool for assessing GJH (Juul-Kristensen, 2017). Examination was taken according to guidelines described by the authors of the test (Beighton & Horan, 1969). According to Malfait *et al*. (2017), a score of five out of nine in Beighton Scale was indicative of hypermobility. Examination was done at a swimming competition where the swimmers were examined after the warm-up while standing.

The measures were non-invasive. The data of the participants were kept anonymous during coding procedures. All participants were informed of the methods to be used and consented to participate in this study. The project was approved by the local ethics committee (93/KBL/OIL/2016) of the university.

Statistical analysis

The results of the examination were compiled using Excel (Microsoft, USA) and STATISTICA PL version 10. (StatSoft, USA). The quantitative results of the analysis were described with the use of number and percentage, minimal, maximal and mean value. The obtained results were subject of the statistical analysis with the use of Spearman's rank test correlation. The t-test and p-value test were applied to check the level of significance that was set at alpha=0.05 ($p<0.05$).

RESULTS

The mean number of training units per week was 10.67±1.04 and mean years of training was 8.25±2.86 years. The mean number of selected acute injuries (sprains/dislocation/fractures) and chronic pain per person in the researched group were 1.33±1.55. Males and females were analysed separately because the prevalence of GJH varies according to gender.

Table 3. **CHOSEN TRAINING, INJURY AND PAIN INDICATORS OF SWIMMERS**

Variables	Males (n=50) M±SD	Range	Females (n=47) M±SD	Range	Total group (n=97) M±SD	Range
Training units per week	10.78±1.06	7-14	10.57±0.93	7-12	10.67±1.04	7-14
Years of training	8.58±2.64	4-14	7.89±3.07	4-16	8.25±2.86	4-16
Acute injuries and chronic pain per person	1.46±1.71	0-7	1.19±1.36	0-5	1.33±1.55	0-7
Acute injuries per person	0.82±1.48	0-6	0.40±0.65	0-3	0.62±1.17	0-6
Chronic pains per person	1.25±1.39	0-4	0.90±1.24	0-4	0.62±1.02	0-4

Of the participants, 61 (62.9%) scored five or more points on the Beighton Scale indicating GJH. Out of 47 females, 36 (76.6%) scored ≥5 points. Among the males, 25 (50%) out of 50 were defined as hypermobile (scored five or more points) (Table 4). Several swimmers (n=37) complained of chronic pain in at least one part of the body. The most common locations of the pain were the knee, shoulder girdle and lumbar spine. (Table 5).

Table 4. **POINTS ACHIEVED BY SWIMMERS ON THE BEIGHTON SCALE**

Beighton Scale points	**Males** (n=50)		**Females** (n=47)		**Total group** (n=97)	
	n	%	n	%	n	%
0	0	0	1	2.13	1	1.03
1	3	6	0	0	3	3.09
2	1	2	4	8.51	5	5.15
3	12	24	3	6.38	15	15.46
4	9	18	3	6.38	12	12.37
5	10	20	6	12.77	16	16.49
6	2	4	5	10.64	7	7.22
7	7	14	15	31.94	22	22.68
8	5	10	4	8.51	9	9.28
9	1	2	6	12.77	7	7.22

Table 5. **NUMBER OF SWIMMERS WITH CHRONIC JOINT PAIN**

Body segments	**Males** (n=50)		**Females** (n=47)		**Total group** (n=97)	
	n	%	n	%	n	%
Shoulder girdle	10	20.0	4	8.51	14	14.43
Spine Cervical	0	0	0	0	0	0
Spine Thoracic	1	2.0	0	0	1	1.03
Spine Lumbar	5	10.0	3	6.38	8	8.25
Knee joint	6	12.0	12	25.53	18	18.56
Ankle joint	0	0	2	4.26	2	2.06

In the researched group, there were 24 (24.7%) swimmers who suffered sprains or dislocation. The most common injury in the swimmers was ankle sprain (n=18) (Table 6). Swimmers also sustained fractures, however, it was the least common type of injury in this group (n=16). The most frequent were fractures of the shin (n=6) (Table 7). There was no statistically significant correlation between the prevalence of GJH and the number of injuries.

However, there were correlations of several investigated features that turned out to be statistically significant (Table 8). Correlations between genders in Beighton Scale score and the number of injuries (acute and chronic) were not statistically significant ($p>0.05$).

Table 6. **NUMBER OF SWIMMERS WITH SELECTED ACUTE INJURIES**

	Males (n=50)		**Females** (n=47)		**Total group** (n=97)	
Body segment	n	%	n	%	n	%
Shoulder	2	4.00	0	0	2	2.06
Knee (kneecap)	2	4.00	2	4.26	4	4.12
Ankle	10	20.00	8	17.02	18	18.56

Table 7. **NUMBER OF SWIMMERS WITH FORMER FRACTURES**

	Males (n=50)		**Females** (n=47)		**Total group** (n=97)	
Body segment	n	%	n	%	n	%
Wrist	2	4.00	1	2.12	3	3.09
Arm	1	2.00	0	0	1	1.03
Forearm	0	0	2	4.26	2	2.06
Shin	5	10.00	1	2.12	6	6.19
Metatarsus	2	2.00	2	4.26	4	4.12

Table 8. SIGNIFICANT CORRELATIONS BETWEEN SELECTED MEDICAL AND AND TRAINING INDICATORS FOR GENDERS

Measures correlated	**n**	**R(Spearman)**	**T(N-2)**	**p-Value**
Males	50			
Body mass - Acute injuries		0.3304	2.4256	0.019095
Years training – Injuries (acute & chronic)		0.3596	2.6702	0.010317
Females	47			
Practice sessions – Beighton Scale		0.3279	2.3284	0.024446
Practice sessions – Acute injuries		-0.4240	-3.1409	0.002975
Total group	97			
Body stature – Beighton Scale		-0.2005	-1.9951	0.048902

DISCUSSION AND PRACTICAL APPLICATION

Prevalence of GJH

Comparing the current findings to previous research (Russek *et al*., 2016; Juul-Kristensen *et al*. 2017), GJH is more prevalent in a group of competitive swimmers than in the general population. Further research is required to determine what the cause of the high prevalence of GJH in a group of professional swimmers is and if this medical condition had an influence on their lives after their athletic career. One of the causes of high prevalence of GJH is probably the flexibility achieved by athletes, due to repetitive stretching exercises (Decoster *et al*., 2006; Page, 2012). However, some researchers consider GJH as a genetically determined component of overall flexibility, which cannot be readily altered by stretching (Smits-Engelsman *et al*., 2011).

To the best of our knowledge, no reports are referring to the prevalence of GJH in competitive adult swimmers. Several studies verify and compare the mobility of joints in the groups of young people trained in several disciplines including swimming. Jansson *et al*. (2005) used Beighton Scale to investigate120 children (two groups: 9- and 12-year-old) where the trained swimmers were compared with controls. Male swimmers of both age groups showed a higher degree of GJH compared to the reference group, while 9-year-old female swimmers alone had a lower degree of GJH when compared. However, these outcomes are difficult to compare to this research due to the age difference of the groups studied. Two other reports show only differences in mobility in selected joints of young swimmers and do not refer to GJH or any medical condition (Maffulli et al., 1994; Torres & Gomes, 2009).

Correlation of GJH and pain

In the current research, there was no significant correlation between chronic pain and GJH, however more profound, clinical examination may lead to prove this correlation. According to Bin Abd Razak *et al*. (2014), GJH is highly related to musculoskeletal injuries. Using the Beighton Scale, they examined 100 individuals who reported musculoskeletal injury and 100 controls without injury. Those with hypermobility were over three times more numerous in the group of injured than in the control group.

Russek and Errico (2015) evaluated the prevalence of GJH, the number, types and location of sustained injuries and other symptoms often connected to GJH within the population of healthy students. Analysis of the cutoff ≥5/9 of the Beighton scores showed that the overall prevalence of GJH was 26.2%, with a prevalence of 36.7% among females and 13.7% among males. The researchers did not find a correlation between injuries and GJH, however, they only investigated the link between the number of sprains and back pain in a group of individuals with GJH. The findings of our study were in agreement with those reported by Russek and Errico (2015).

No significant correlations were found between the prevalence of GJH and the number of injuries and chronic pain. Perhaps the physical activity of swimmers expands the strength of their muscles that provides dynamic stability and proprioception in the joints (Lord *et al.*, 1996) and prevent repetitive micro-traumas, which are the plausible cause of chronic joint pain. Dynamic stability and proprioception in the joints also prevent acute injuries, such as strains and sprains (Mattacola & Dwyer, 2002). Outcomes of GJH in swimmers might be noted after they stop training, but to confirm that hypothesis, more research is needed.

Common injuries and pain

In this study, only 14% of the swimmers reported chronic shoulder pain (on the assumption that chronic pain lasted at least one month). Previous studies show that pain episodes occur in up to 90% of swimmers, mostly in the shoulder girdle (Torres & Gomes, 2009). Walker *et al*. (2012) examined 74 competitive swimmers, of which 23% suffered from shoulder pain that lasted at least two weeks. Liaghat *et al*. (2018) who examined muscular strength of young competitive swimmers with generalised and shoulder joint hypermobility (GJHS), proved that those athletes displayed both strength and fatigue deficits in medial rotation, which maybe some of the contributing mechanisms for the development of shoulder injury.

The results indicated that chronic pain was most common in the knee, where over 18% of the participants reported pain. According to literature, the prevalence of knee problems requiring an orthopaedic consultation was 34% among the 35 members of the 1972 Canadian Olympic swimming team (Kennedy *et al*., 1978). Soder *et al*. (2012) investigated MRI of the knees of asymptomatic adolescent elite swimmers and found at least one imaging abnormality in 69.2% of swimmers.

Ristolainen *et al*. (2009) investigated several injuries in a group of 583 competitive Finnish athletes (cross-country skiers, swimmers, long-distance runners and soccer players). In a group of 158 swimmers, 63% males and 65% of females were injured during the past twelve-month period. Overuse injuries were noted in 51% of the males and 52% of the females. In the total group of 583 athletes, overuse injuries were most commonly localised around the heel and Achilles tendon. The knee was the second most commonly injured body part where 18% of the females and 16% of the males were affected.

Sprains and/or dislocations were suffered by over 24% of the swimmers of the current study. Injuries were most commonly localised in the ankle (over 18%). According to Ristolainen *et al*. (2009), among swimmers, 38% of the males and 27% of the females suffered from acute injuries. In their total study group (N=583), acute injuries most commonly occurred in the ankle (35% of the females and 26% of the males).

Gender differences

According to our research, both sprains/dislocations and chronic pain were more common among males where 28% of the males suffered from sprains or dislocations compared to 21% of the females. Chronic pain was experienced by 44% of the males and 40.4% of the females. Those gender differences, however, were not statistically significant ($p>0.05$).

This proportion is different from those described by Sallis *et al*. (2001) in a retrospective cohort study of injury reports compiled by certified athletic trainers between Fall 1980 and Spring 1995. A statistically significant gender difference in injury incidence ($p<0.001$) was seen for two sports: swimming and water polo. Sallis *et al*. (2001) noted 47.08 injuries per 100 participant-years in a group of females and only 12.37 injuries per 100 participant-years in a group of males. The authors believe that the more rigorous training regimen used by the women's coach may have contributed to the higher number of injuries in this study that were found in the female athletes competing in water sports (Sallis, 2001).

Ristolainen *et al*. (2009) showed that, when combining acute and overuse injuries of the ankle and the knee among all athletes, no difference was observed in the proportion of injured athletes between females (49%) and males (41%) ($p=0.13$). Also in the study of Yang *et al*. (2012) on 573 injured competitive collegiate athletes, they report the gender difference was

not statistically significant, with 48.3% versus 51.7% for overuse injuries and 54.0% versus 46.0% for acute injuries in males and females respectively.

LIMITATIONS

History of injuries was based on the information gathered by means of the interview and not from the documentation of medical history. However, participants were asked in detail about injuries and pains (contact with medical doctor, diagnosis, duration of pain and other manifestation, medical procedures received). Another limitation of this study is the relatively small number of participants. This limitation comes from fact that in Poland there are not many athletes who actively train for swimming. To increase the number of participants, swimmers from other countries could be examined.

CONCLUSIONS

GJH is an often-occurring symptom among the researched group of competitive swimmers. There was no correlation between selected acute injuries (sprains, dislocations, fractures) and GJH in study group also there was no correlation between chronic pain and GJH in a study group. Several relationships were noted between anthropological and training indicators and number of injuries, as well as between anthropological and training indicators and Beighton Scale results.

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