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ORIGINAL ARTICLE

OPEN VERSUS CLOSED REDUCTION IN HUMERAL SHAFT FRACTURES: COMPARATIVE STUDY BETWEEN INTRAMEDULLARY NAILING AND PLATING

OTWARTE A ZAMKNIĘTE ZREDUKOWANIE ZŁAMAŃ TRZONU KOŚCI RAMIENNEJ: BADANIE PORÓWNAWCZE MIĘDZY GWINTOWANIEM ŚRÓDSZPIKOWYM A PŁYTOWANIEM

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ABSTRACT

Introduction

Humerus shaft fractures (HSF) represent 1 to 5% of all fractures in adults. Most HSFs can be managed conservatively. However, there are reports that operative treatment can lead to better outcomes, but with a higher risk of complications.

Aim

To evaluate clinical and functional outcomes of Humeral Shaft Fracture (HSF) treatment with intramedullary (IM) nail or locking plate.

Material and methods

72 patients were evaluated with a mean follow-up of 38.3 months. Functional results were evaluated using The Disabilities of Arm, Shoulder and Hand scale (DASH), Numeric Pain Rating Scale (NRS) Subjective Shoulder Value (SSV).

Results

42 patients were treated with IM nailing and 20 with plating. 18 (29.0%) complications occurred within 30 days and 14 (16.1%) within 6 months. There were significantly more transient neurological complications within 30 days from surgery in patients with plate fixation. Revision surgery was required in 10 (16.1%) and nonunion developed in 2 (2.7%) cases without the significant difference between fixation groups.

Conclusions

Fixation of humeral shaft fracture with plate can more often result in transient neurological complications in early postoperative period than nailing. No statistically significant difference in functional results nor other complications were reported.

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STRESZCZENIE

Wprowadzenie

Złamania trzonu kości ramiennej (HSF) stanowią od 1 do 5% wszystkich złamań u dorosłych. Większość takich złamań można skutecznie leczyć zachowawczo. Niemniej jednak, istnieją doniesienia sugerujące, że leczenie operacyjne może prowadzić do lepszych wyników klinicznych, choć wiąże się z większym ryzykiem powikłań.

Cel

Ocena wyników klinicznych i funkcjonalnych leczenia złamań trzonu kości ramiennej (HSF) za pomocą gwoździ śródszpikowych (IM) lub płytek blokowanych.

Materiał i metody

Przeanalizowano dane 72 pacjentów, których średni czas obserwacji wyniósł 38,3 miesiąca. Wyniki funkcjonalne oceniano za pomocą skali Disabilities of Arm, Shoulder and Hand (DASH), Numeric Pain Rating Scale (NRS) oraz Subjective Shoulder Value (SSV).

Wyniki

42 pacjentów leczono gwoździami śródszpikowymi, a 20 płytkami blokowanymi. W ciągu pierwszych 30 dni po operacji odnotowano 18 (29,0%) powikłań, natomiast w okresie 6 miesięcy wystąpiło ich 14 (16,1%). Znacząco więcej przejściowych powikłań neurologicznych w ciągu 30 dni odnotowano u pacjentów leczonych za pomocą płytek. Konieczność przeprowadzenia rewizji chirurgicznej dotyczyła 10 (16,1%) przypadków, a brak zrostu zaobserwowano w 2 (2,7%) przypadkach, bez istotnej statystycznie różnicy pomiędzy grupami.

Wnioski

Stabilizacja złamania trzonu kości ramiennej za pomocą płyt blokowanych częściej prowadzi do przejściowych powikłań neurologicznych w początkowym okresie pooperacyjnym w porównaniu z gwoździowaniem. Nie zaobserwowano istotnych statystycznie różnic w wynikach funkcjonalnych ani w występowaniu innych powikłań.

Słowa kluczowe: Złamania trzonu kości ramiennej, skale oceny subiektywnej, leczenie za pomocą gwoździ śródszpikowych (IM) lub płytek blokowanych

Introduction

Humerus shaft fractures (HSF) are defined as fractures located between the insertion of pectoralis major tendon proximally and the supracondylar ridge distally and represent 1 to 5% of all fractures in adults (Brinker and O'Connor 2004; Spiguel and Steffner 2018). Their prevalence with age has got two peaks. First in males in their 3rd decade of life and second in females of 60-80 years of age. In the former these are high energy injuries, in latter low energy injuries (Oliver *et al.,* 2020; Rämö *et al.,* 2020). Fractures of proximal and middle third of humeral shaft are considered fragility fractures (Oliver *et al.,* 2020). Most of HSFs can be managed conservatively. However, there are reports that operative treatment can lead to better outcomes, but with a higher risk of complications (Matsunaga *et al.,* 2017; Westrick *et al.,* 2017). Increasing tendency toward surgical treatment is observed in the

literature, now reaching up to 50% of the cases treaded primarily by a surgery (Huttunen *et al.*, 2009; Tzioupis and Giannoudis 2007). Upper limb function remains acceptable if after primary reduction humerus deformity is no more than: 20 degree of angulation in the anterior-posterior plane, less than 30 degree of varus valgus of rotational deformity and 3 cm shortening (Shields *et al.*, 2016). Open fractures and arterial injury are an absolute indications for surgical treatment. Many types of surgical treatment of HSFs are recommended: an ante- or retrograde intramedullary nailing, as well as locking plate fixation in an open or mini-open technique (García-Virto *et al.*, 2021; Lian *et al.*, 2013; Ouyang *et al.*, 2013). Depending on the fracture configuration a wire cerclage can be used with other forms of fixation.

The aim of this study is to present the results of surgical HSF treatment in our Trauma and Orthopedics department from 2013 to 2020. Our hypothesis was that open reduction increases risk of complications compared to closed techniques.

Materials and methods

Data of 201 patients (117 women and 84 men) with HSF in a period from 2013 to 2020 were reviewed. Patients primarily treated in other medical centers and patients who presented with established nonunion were excluded from the analysis. For plating the fractures antero-lateral or triceps splitting approaches were used depending on fracture location. Locking compression plates (LCP) of two types were used: Stryker Variax (USA, 2825 Airview Blvd. Portage, MI 49002) and LCP Synthes (USA, 1302 Wrights Lane East West Chester, PA 19380). For IM fixation rotator cuff splitting or saving technique was used, with proximal and distal blocking. In cases where cerclage wire was used fracture site was opened and reduced before inserting the IM nail. IM nails of two types were used: Targon H (Geramany, Carl-Braun-Straße 1, 34212 Melsungen, Hessen) and CHM Charfix2 (Poland, Lewickie 3b, 16-061 Juchnowiec Kościelny). Analysis was based on medical documentation, x-rays, outpatient clinic visits and phone calls evaluating results of treatment in a period of up to 30 days and period above six months from the surgery. In the analysis of patients functional scales were used: The Disabilities of Arm, Shoulder and Hand scale (DASH), Numeric Pain Rating scale (NRS) and Subjective Shoulder Value (SSV) (Gilbart and Gerber 2007; Hudak *et al.*, 1996; Williamson and Mbbs). End points of the evaluation were defined as lack of pain, lack of pathological movement and callus formation in the fracture area in the X-Ray evaluation after at least six months after the surgery. Ethical approval was granted by the local Ethics Committee of Medical Center of Postgraduate Studies in view of the retrospective nature of the study and all the procedures being performed were part of the routine care.

Statistical Analysis

For statistical analysis Microsoft Excel 2019 (Microsoft, Washington, USA) and Statistica 13.1 (Tibco Software Inc., California, USA) software were used. Continuous variables of demographical and clinical data as means and standard deviation (±SD) were presented. Shapiro-Wilk test was performed to determine the normality of data. Statistical differences were calculated with the use of Chi2, Kruskal-Wallis and Mann-Whitney U tests.

Results

72 patients (35.8%) were treated surgically: 32 (44.4%) women and 40 (56.6%) men. There were 25 cases of 12A1, four 12A2, ten 12A3, four 12B1, seven 12B2, two 12B3, three 12C1, four 12C2 and three 12C3 fractures according to AO-OAT classification. 42 patients (67.7%) were treated with IM nail and 20 (32.3%) with plate fixation. Early evaluation within 30 days, focused on complications evaluation. It was conducted in 62 (83.9%) patients, ten patients were lost for follow-up. Out of these 54 (87.1%) patients were evaluated after six months since the surgery. The average follow-up was 46.5 months – ranging from 13 to 90 months. In 17

(27.4%) patients data was collected from the medical reports, in 37 (59.7%) functional evaluation was conducted using DASH, NRS and SSV scale during clinical control or phone call. Demographic and clinical data, distribution of the fractures localization and methods of treatment are presented in Table 1.

DASH and SSV and lower values of NRS were reported in patients with bone union comparing to patients with complications and revision surgery, however the results were not statistically significant.

Table 1. Demographic and clinical data.

	Total	**Plate**	**IM Nail**	**P**
Males/Females	32/30	14/6	18/24	0.72*
Age	52 (±18.3)	35 (±15.5)	60 (±13.5)	**< 0.001****
BMI	28 (±5.0)	28 (±5.7)	28 (±4.7)	0.78**
Post surgery neurological complications up to 30 days post-operation	12	8	4	**< 0.003***
Neurological complications in six months and above	4	2	2	0.11*
Revision surgeries after primary fixation	10	5	5	0.15*
All complications above six months	15	6	9	0.46*
Proximal fractures	17	1	16	
Mid shaft fractures	27	3	24	
Distal fractures	18	15	3	
*chi test				
**U Mann-Whitney test				

Early complications within 30 days from the surgery were reported in 18 (29.0%) patients (Table 2). Most of them were radial nerve neuropraxia. All five preoperative nerve palsies fully recovered after the surgery. There were statistically significantly more neurological complications in this early postoperative period in patients treated with LCP than IM nail ($p = 0.0026$). In a period over six months fracture union was achieved in 52 out of 54 patients (96.3%) with 15 (27.8%) complications and ten (18.5%) revision surgeries. These are summarized in Table 2. No statistically significant difference in complications rate was observed neither between LCP and IM nail groups ($p = 0.46$) nor between fracture types after six months from surgery ($p = 0.24$).

Functional Results

Functional results were clinically evaluated in 37 patients (Table 3). Mean observation period was 38.3 months (from six to 84 months). A tendency for better results in

Discussion

Historically HSF non-operative treatment, particularly using functional bracing reported by Sarmiento, used to be a treatment of choice with good results. (Kapil Mani *et al.*, 2013; Sarmiento *et al.*, 1977). Despite this fact there is a tendency to use more aggressive approach with a surgical treatment, which is associated with a lower risk of non-unions. (Huttunen *et al.*, 2012; Schoch *et al.*, 2017). However risk of complications associated with surgical exposure as radial nerve palsy and post-operative infection needs to be weighted in each case. (Gallusser *et al.*, 2021) A tendency to use less invasive techniques such as closed nailing or minimally invasive percutaneous plating (MIPO) leaving fracture site almost intact to prevent extensive soft tissue stripping also seems to be a viable alternative with good preliminary results (García-Virto *et al.*, 2021; Kulkarni *et al.*, 2017).

In this study, we believed that less invasive technique using closed nail fixation would result in lower rate of complications.

Table 2. Complications observed.

Complications observed up to 30 days			
	Total	**Plate**	**IM Nail**
Radial nerve palsy out of which 5 (8.1%) were reported pre-operatively	15 (24.2%)	7 (1 pre-operatively)	8 (4 pre-operatively)
Ulnar nerve palsy	1 (1.6%)	1	0
Ulnar and radial nerve palsy	1 (1.6%)	1	0
Straight plate destabilization requiring plate reosteosynthesis with wires	1 (1.6%)	1	0
Complications observed above 6 months			
Superficial infection treated with oral antibiotic only	1 (1.9%)	0	1
Allergy to the metal resulted in heavy radial nerve palsy due to callus entrapment. Required implant removal	1 (1.9%)	0	1
Radial nerve paresis after hardware removal	1 (1.9%)	1	0
Radial nerve paresis described in EMG examination – no clinical symptoms	1 (1.9%)	0	1
Radial nerve paresis (one case I–III fingers extension impairment, one sensory deficits, one general partial paresis, one neuralgy)	3 (5.6%)	2	1
Pseudoarthrosis	2 (3.7%)	2	0
Mechanical implant complications (1 acromial hardware conflict, 1 improper method of osteosynthesis to the fracture type required change, hardware break after a fall, 3 hardware destabilisations	6 (11.1%)	1	5
Revision surgeries			
Destabilisation of internal fixation	3 (4.8%)	2	1
Hardware conflict with acromion	2 (3.2%)	0	2
Inadequate primary stabilization technique chosen for the fracture type	1 (1.6%)	0	1
Allergic reaction to the metal	1 (1.6%)	0	1
Patient intolerance of hardware	3 (4.8%)	3	0

IM – intramedullary; EMG – electromyography

42 (67.7% of all operated patients) of fractures was fixed with IM nail. Only in one patient (2.3% of IM nail fixation and 1.6% of all patients respectively) with a clear technical problem the revision surgery with plate fixation was necessary in early postoperative period (Figure 3).

Non-union rate reported in the literature ranges from 0 to 14% [5–7, 20, 32]. More non-unions seems to be related with nail fixation (Tzioupis and Giannoudis *et al.*, 2007). In our study two non-unions were reported in plate fixation group (10%) and no non-union was reported in IM fixation group. Reasons for such results could be: surgeon experience, type of fracture and patient related factors (Zura *et al.*, 2016). However we did not find any statistically significant differences comparing these factors. In the literature non-union rates after plate fixation range from 3.5% to 14.0% in an open type fixation and 4% to 10% in MIPO techniques (Akalın *et al.*, 2020; Benegas *et al.*, 2019; Changulani *et al.*, 2007; Daglar *et al.*, 2007; Singisetti and Ambedkar 2010).

Neurological complications were observed in 15 cases (24.2%) in an early postoperative period. In case of plate fixation there was a significantly higher risk of neurological complications than in nail fixation ($p = 0.0026$). They occurred in eight patients (19.0%) treated with IM nail and seven (35.0%) with plate. In six (30.0%) plate cases and four (9.5%) IM cases neurological complications appeared postoperatively. In all cases of IM nail fixation it was radial nerve palsy. In plate group the most

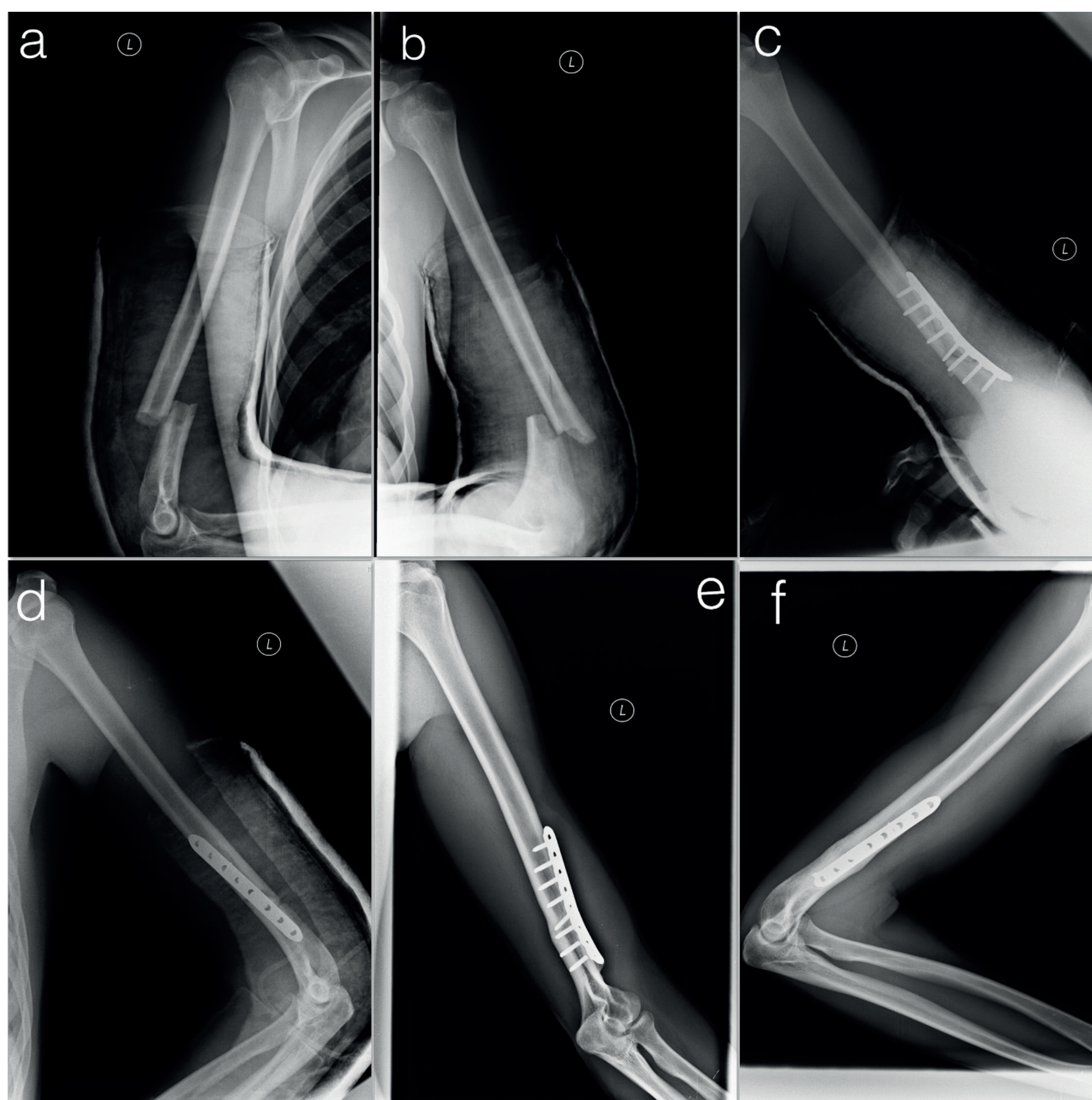

Figure 1. X-ray of distal 1/3 humerus fracture. Pre-operative (a, b), post-operative (c, d) and after eight months from the surgery (d, e)

common was radial nerve palsy observed in seven (35.0%) cases but there was also one (5.0%) case of radial and ulnar nerve palsy and one case (5.0%) of isolated ulnar nerve palsy. In the literature prevalence of the radial nerve palsy is less common after nailing compared to plating (2.6% and 15% respectively) (Belayneh *et al.,* 2009; Changulani *et al.,* 2007; Chapman *et al.,* 2000; Schwab *et al.,* 2018; Singisetti and Ambedkar 2010). In a period over six months from the surgery neurological symptoms persisted equally in three cases of plate fixation (15.0%) and IM fixation (7.1%), but this difference did not reach any statistical significance. All preoperative nerve palsies recovered after surgery (Table 2). These results suggest that there was probably inadequate surgical technique causing higher than in comparable studies iatrogenic radial nerve injuries in plate fixation group. It seems to be confirmed by really high number of radial nerve palsies in about 1/3 of patients in plate fixation group (Akalın *et al.,* 2020; RG *et al.,* 2000).

In an observation period above 30 days six (11.1%) revisions were performed in a group of 42 patients fixed with IM nail. In one (2.4%) case it was due to improper fixation technique, in three (7.14%) patients due to fixation failure. In one (2.4%) patient due to allergic reaction

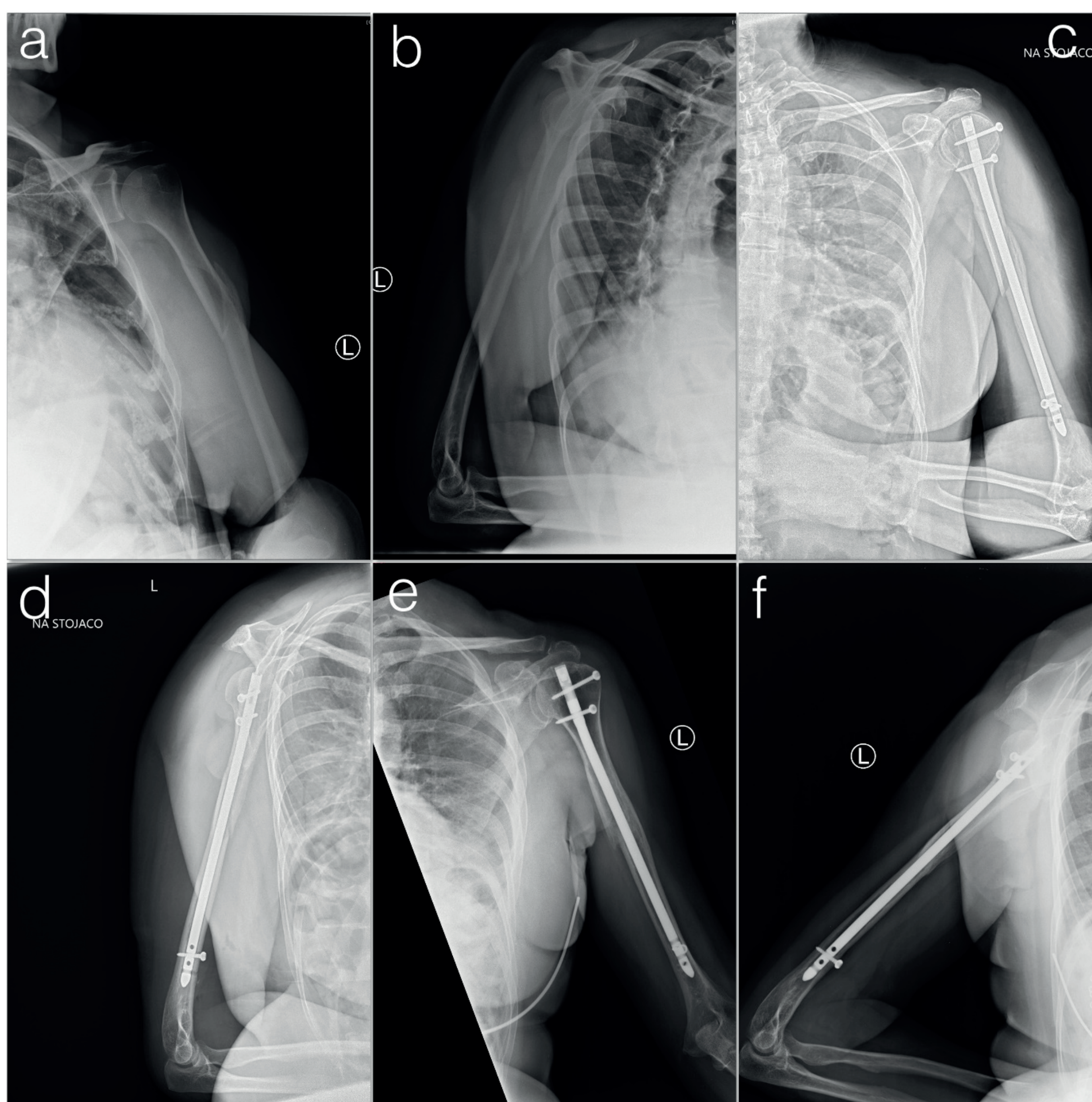

Figure 2. X-ray of middle 1/3 humerus fracture. Pre-operative (a, b), post-operative (c, d) and after 13 months from the surgery (d, e)

to implant it was necessary to remove it and in one (2.4%) case due to hardware protrusion and conflict with acromion. In literature reoperation rate after IM nailing ranges from 5.5% to 17.4% (Changulani *et al.*, 2007; Chapman *et al.*, 2000; Daglar *et al.*, 2007) and hardware protrusion rate reaches around 6% in comparable studies (Belayneh *et al.*, 2019; Putti *et al.*, 2009). Nevertheless, five cases of revision in our study were related to a technical error.

In plate fixation group five (25.0%) patients required revision surgery: one (5.0%) due to nonunion, one due to fixation failure and three (15.0%) due to poor implant tolerance by the patient. Metal removal in Chapman et. al. work was estimated to 2% and fixation failure in McCormac's et. al. was estimated as 4.5% (Chapman *et al.*, 2000; RG *et al.*, 2000). These values were significantly lower than in our study, which can also confirm some technical problems. Statistical analysis of complications rate depending on fracture level and fixation used did not show any statistical significance and to our knowledge there is no study describing such relationship.

Functional results can be compared in DASH scale and by extrapolation of NRS scale to VAS (visual analogue scale) as there are no other studies evaluating arm function by NRS scale.

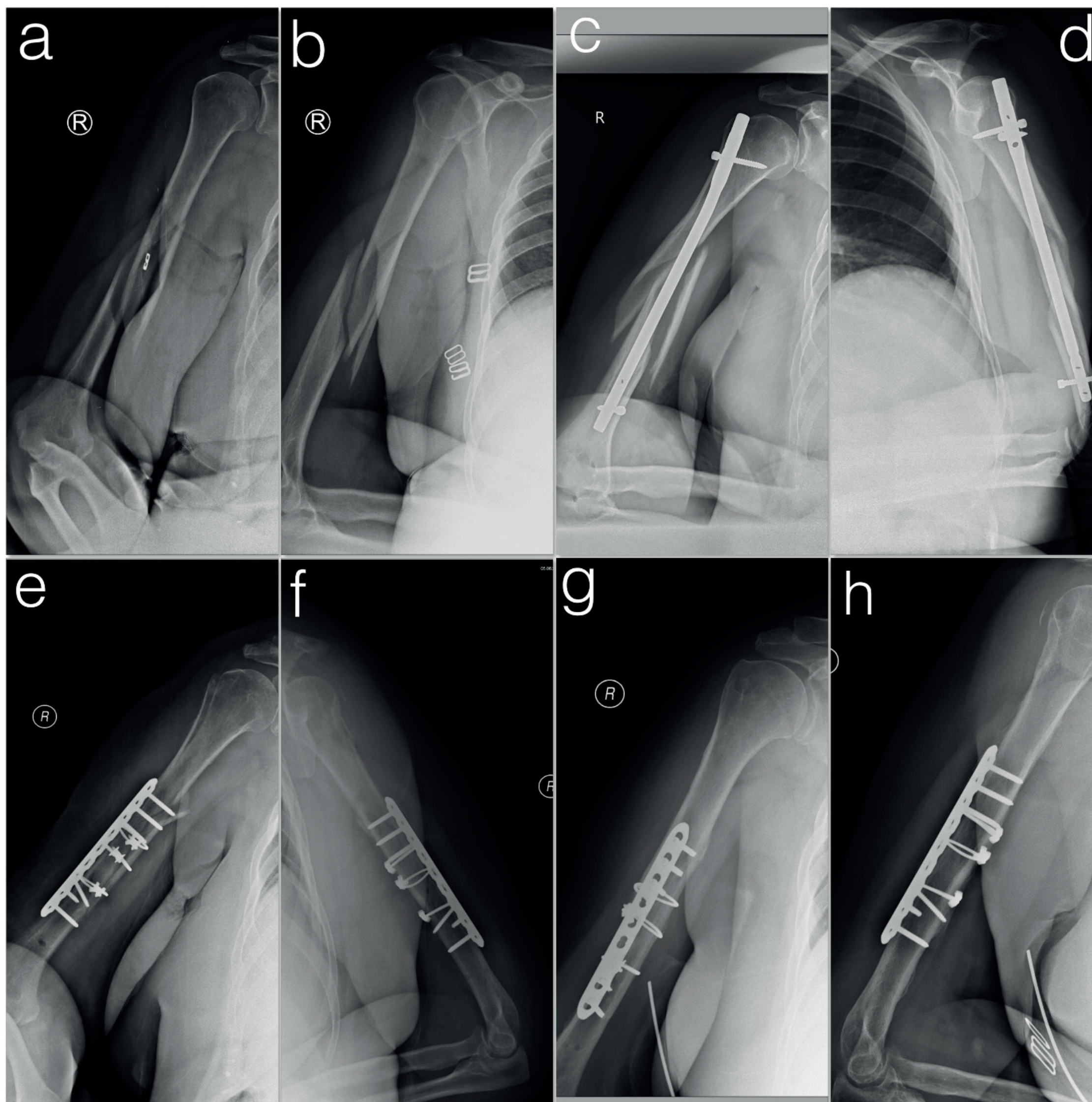

Figure 3. X-rays presenting inadequately chosen primary stabilization technique of middle 1/3 of humeral shaft (a, b) with intra medullary nail (c, d). Revision surgery was conducted within 6 weeks from initial surgery with change of IM nail to LCP plate with cerclage wire (e, f). X-ray 7 months after the surgery with bone healed (g, h)

None of comparable works used SSV as a functional result of HSF, however patient self-evaluation of upper extremity seemed to the authors very useful. Patients who did not require revision presented tendency to better functional scale results than patients who required revision. The same tendency was found between patients with healed fractures versus patients with pseudarthrosis. Due to small groups included into functional evaluation no statistical significance was found.

This study results should be compared to Akalin *et al.* study who noted better functional results in the University of California at Los Angeles (UCLA) shoulder score for plate fixation and higher VAS scores in patients treated with IM nail in long-term follow-up. However no statistical difference was found using DASH scale. [1]. DASH scale results in patients who did not required revision are similar as in Zhang *et. al.* study – authors did not observe statistically significant difference in DASH and VAS results after different methods of surgical treatment (Zhang *et al.,* 2020).

Absolute values for patients not requiring revision surgery are better than in Zhang's *et al.* study – DASH for our patients operated with IM nail and plate are respectively 23.76 and 22.37 (Zhang *et al.,* 2020).

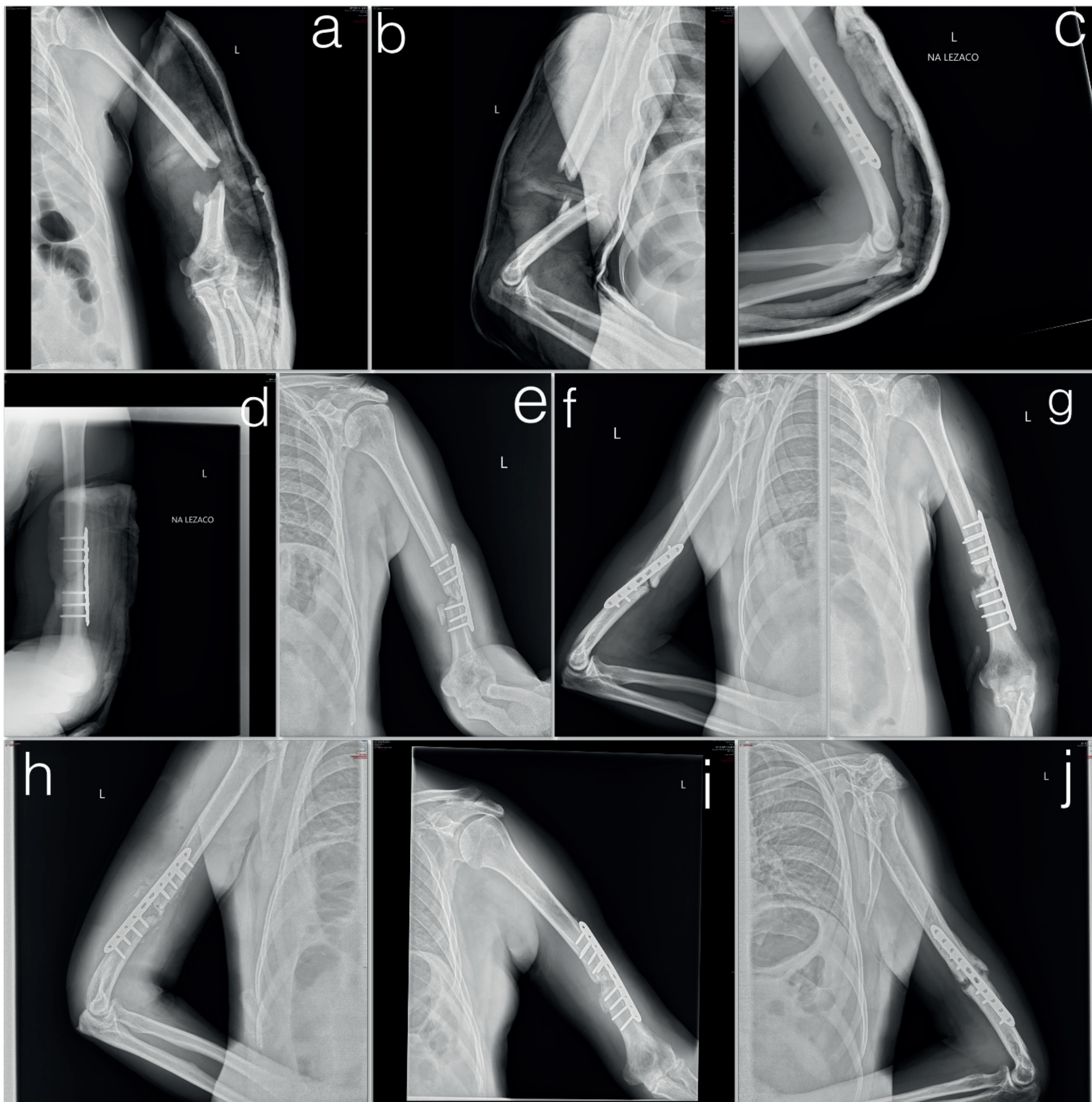

Fig. 4 Distal 1/3 humeral shaft fracture x-rays (a,b) fixed primarily with a straight plate c and d are post-operative x-rays. Five months after initial surgery revision was made due to implant failure (e,f). Patient reoperated (g,h) and after 3.5 year since initial surgery pseudarthrosis persists with progressive angular deformation (i,j), patient does not want to reoperate.

Interesting is fact that in Ranstam et. al. study patients treated functionally had DASH score 12.0 which is comparable for all surgically treated group (DASH 13.1) with revisions and pseudarthrosis patients (Rämö *et al.,* 2020). In our study range of motion of the ipsilateral shoulder was: flexion 169.0˚ (±25.6), abduction 165.9˚ (±27.7), external rotation 56.2˚ (±11.0) and in revision group 153.3˚ (±46.8); 150.0˚ (±45.5); 60.0˚ (±14.1) respectively. These are better results than in Park et. al. study who used the same method of functional evaluation of HSF (Park *et al.,* 2008).

This study has some very important limitations. First limitation could be heterogeneity of compared groups. Age of patients who were operated with plate is twice lower than patients operated with IM nail thus all observed differences can be assigned not only to the mode of treatment but also to the age of patients. However it is still hard to ascribe more neurological complications in period of 30 days from the surgery in group of patients operated with plate to the age difference between two groups. Second limitation is small group of patients controlled after more than six months from

Table 3. Functional results.

	All operated patients with functional scales evaluation n = 37	Patients healed without any revision surgery n = 27	Patients who developed pseudoarthrosis n = 2	Patients who required reoperation n = 10	p value *
NRS scale	0.92 (STD 1.60)	0.59 (STD 1.06)	3.00 (STD N/A)	1.88 (STD 2.57)	0.64
Subjective function evaluation	83.71% (STD 21.88)	89.00% (STD 9.66)	60.00% (STD N/A)	68.13% (STD 29.78)	0.38
DASH score	13.09 (STD 19.26)	8.1 (STD 8.74)	40.5 (STD N/A)	31.19 (STD 31.96)	0.21

*Kruskall Wallis test

Table 3 NRS and functional results of SSV and DASH scale with mean value and standard deviation. NRS-numeric rating scale; SSV subjective shoulder value; DASH The Disabilities of the Arm Shoulder and Hand score; SD-standard deviation.

surgery – 40% of patients were lost to follow-up. Possible reason for this situation is long period taken to analysis (seven years) and fact that patients operated in our center come from remote parts of whole country which makes follow-up more difficult. Another limitation of this study is lack of comparison to functionally treated patients, which arises from different aim and methodology of this paper. The advantage of this study is honest and meticulous description of all technical complications reported by relatively experienced team of surgeons operating in a reference center. This study despite all its limitations confirm our hypothesis, that open surgery with plate fixation can create more complications, particularly concerning early neurological problems. However, less invasive IM fixation requires very meticulous technique, as need for hardware removal is related with technical problems.

Conclusion

Functional and radiological results of surgical treatment of HSF are satisfactory, however complications in patients treated with plate fixation were found more often than in comparable studies in the literature. Also, in patients treated with plate fixation significantly more neurological complications were reported in early postoperative period. There is a tendency toward better functional results in patients after primary surgery compared to patients who required revision surgery or developed nonunion. Open reduction with plate fixation can create more complications, particularly concerning early neurological complications. However, less invasive IM fixation requires very meticulous technique, as potential hardware removal is related with technical problems.

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ORIGINAL ARTICLE

WINTER SPORTS PRACTICE IN POLAND: CHARACTERISTICS, INJURIES AND RISK FACTORS

UPRAWIANIE SPORTÓW ZIMOWYCH W POLSCE: CHARAKTERYSTYKA, URAZY I CZYNNIKI RYZYKA

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ABSTRACT

Introduction

As much as 13% of Poles declare active skiing or snowboarding. Literature has identified many risk and protective factors for winter sports injuries. However, their significance is not fully defined and due to the authors knowledge, literature concerning winter sports injuries in Poland is lacking.

Aim

To examine the characteristics of practicing winter sports, injuries related to them and analyze potential risk and protective factors.

Material and methods

This was a survey study. Inclusion criteria were: age 18–60, exclusion criteria were: injury of the same body part not related with winter sports in last three years and chronic musculoskeletal diseases. The statistical method was Chi-square, ANOVA with post-hoc tests and logistic regression for multivariable analysis of potential risk and protective factors. All p-values were two-tailed and significancy threshold was < 0.05.

Results

523 persons completed the questionnaire. After implementing study criteria, 416 people (271 men and 145 women) were included in the study. 315 people were skiing, 154 people were snowboarding, 85 people were ski touring. 199 people were injured during practicing winter sports. Most often were knee injuries (n = 76), shoulder injuries (n = 52) and wrist injuries (n = 36). Risk factors were: more experience (OR = 1.04, 95%CI = 1.01–1.07) and skiing (OR = 1.93, 95%CI = 1.10–3.40), while strength training in off-season was a protective risk (OR = 0.44, 95%CI = 0.22–0.87).

Conclusions

In Polish winter sports participants the most commonly injured sites were the knee, shoulder and wrist. More experience and skiing were associated with higher risk of injury, while strength training in off-season was associated with lower risk of injury.

Keywords: skiing, snowboarding, prevention, training, experience

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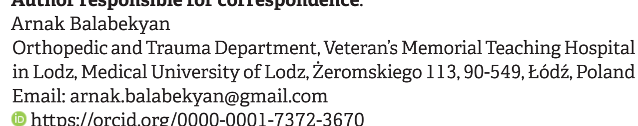

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STRESZCZENIE

Wstęp

Aż 13% Polaków deklaruje aktywne uprawianie narciarstwa lub snowboardu. W literaturze zidentyfikowano wiele czynników ryzyka i ochronnych urazów podczas uprawiania sportów zimowych. Istotność tych czynników nie jest jednak w pełnio kreślona, a zgodnie z wiedzą autorów istnieją braki w obrębie literatury dotyczącej urazów w sportach zimowych w Polsce.

Cel pracy

Zbadanie specyfiki uprawiania sportów zimowych, urazów z nimi związanych oraz analiza potencjalnych czynników ryzyka i czynników ochronnych.

Materiał i metody

Było to badanie ankietowe. Kryteriami włączenia były: wiek 18–60 lat, kryteriami wykluczenia były urazy tej samej części ciała niezwiązane ze sportami zimowymi w ciągu ostatnich trzech lat oraz przewlekłe choroby narządu ruchu. Do analizy statystycznej zastosowany testy Chi-kwadrat, ANOVA z testami post-hoc i regresję logistyczną dla wieloczynnikowej analizy potencjalnych czynników ryzyka i czynników ochronnych. Wszystkie wartości p były dwustronne, a próg istotności wynosił < 0,05.

Wyniki

Ankietę wypełniły 523 osoby. Po spełnieniu kryteriów badania do badania włączono 416 osób (271 mężczyzn i 145 kobiet). 315 osób jeździło na nartach, 154 na snowboardzie, 85 uprawiało skitouring. Podczas uprawiania sportów zimowych 199 osób doznało urazu. Najczęściej były to urazy kolana (n = 76), barku (n = 52) oraz urazy nadgarstka (n = 36). Czynnikami ryzyka były: większe doświadczenie (OR = 1,04, 95%CI = 1,01–1,07) oraz jazda na nartach (OR = 1,93, 95%CI = 1,10–3,40), natomiast trening siłowy poza sezonem stanowiło czynnik ochronny (OR = 0,44, 95%CI = 0,22–0,87).

Wnioski

U polskich zawodników sportów zimowych najczęściej kontuzjowanymi miejscami były staw kolanowy, barkowy i nadgarstek. Większe doświadczenie i jazda na nartach wiązały się z większym ryzykiem kontuzji, podczas gdy trening siłowy poza sezonem wiązał się z niższym ryzykiem kontuzji.

Słowa kluczowe: narciarstwo, snowboard, prewencja, trening, doświadczenie

Introduction

The growing popularity of winter sports and increasing number of ski slopes caused that in 2021, as much as 13% of Poles declared active skiing and snowboarding (Vanat, 2022). In the 2018/2019 season, there were as much as 1766 interventions of Mountain Volunteer Search and Rescue Beskids on ski areas. The most common causes of intervention were limb injuries (81%). Help was mainly provided to skiers (75%) and snowboarders (22%) (GOPR Beskidy, 2019). In the literature many risk and protective factors such as age, sex, skiing experience level, self-assessed skill level, body mass index, specific training, trail difficulty level and equipment fitting were identified up to date (Davey *et al.*, 2019). However, the significance of these factors is not fully defined. What is more, due to the authors knowledge, literature concerning winter sports injuries in Poland is lacking.

Aim

To examine the characteristics of practicing winter sports, injuries related to them and analyze potential risk and protective factors.

Materials and methods

A questionnaire survey was placed in online groups of all sorts of skiers and snowboarders from beginners to professionals. Self-designed questionnaire consisted of five sets of questions covering different issues:

1. **Demographics**: Age, gender, weight, height, type of winter activity (skiing, snowboarding, ski touring), self-assessed level of proficiency in that activity (beginner, intermediate, advanced, professional).
2. **Activity characteristics**: Skiing (on-piste, freeriding), snowboarding (on-piste, freeriding), ski touring.
3. **Off-season training**: Strength training, endurance training.
4. **Injuries sustained during winter sports**: Injuries amount and characteristics (location, type), need for rehabilitation or physiotherapy (self-exercising, supervised rehabilitation/physiotherapy), duration of ruling out from sport-related activity, pain duration.
5. **Comorbidities**: Chronic musculoskeletal or rheumatic disorders.

Responders could choose more than one activity. Responses were further analyzed statistically, using Statistica 13.1 software. The statistical method was Chi square ($\chi 2$) test, ANOVA with post-hoc tests and logistic regression for multivariable analysis of potential risk and protective factors. All p-values were two-tailed and significancy threshold was set at less than 0.05. 523 people responded to the survey. After implementation of study criteria, 416 people remained. Detailed data with inclusion and exclusion criteria was summarized in the Figure 1.

The included skiers consisted of 271 men and 145 women, with an average age of 32.06 years (SD = 9.49). The average height was 175.83cm (SD = 10.31), the average body weight 74.16kg (SD = 14.45) average BMI (body mass index) 23.86 (SD = 3.49). Data of skiers self-assessed skill level was presented in Figure 2.

They practiced winter sports for on an average of 16.7 years (SD = 10.51). This duration differed significantly depending on the declared level of proficiency ($p < 0.001$) and it was: for beginners 2.79 years (SD = 2.62); intermediate 11.36 years (SD = 7.83); for advanced 20.29 years (SD = 9.9 7); for professionals 22.45 years (SD = 10.35). 315 people were skiing, 71 of them performed freeride. 154 people were snowboarding, 45 of them performed freeride. 85 people performed ski touring. 131 people were performing some kind of off-season training. Among those, 95 were performing strength training and 97 were performing endurance training.

Results

Among people who met study criteria 199 (47.84%) people were injured during winter sports practice. Among those were 134 men (49.45% of men) and 65 women (44.83% of women). 158 people suffered soft tissue injuries (106 men; 52 women) and 85 people suffered bone tissue injuries (61 men; 23 women). Detailed data was summarized in the Table 1.

121 of the 199 participants who experienced an injury performed any rehabilitation or physiotherapy, including 35 who were self-exercising without any supervision. Injuries ruled out participants of the survey from any sport-related activity for an average of 4.44 months (SD 8.03). Pain continued through average 10.73 months (SD 15.14).

Concerning overall injury risk, calculated risk factors were: skiing (compared to snowboarding and ski-touring) and more experience; while strength training was a protective factor. Detailed data was summarized in the Table 2.

As to the soft tissue injury risk, more experience turned out to be a risk factor, while strength training a protective factor. Detailed data was summarized in the Table 3.

Figure 1. Flowchart of patients included and excluded from the study, with reasons

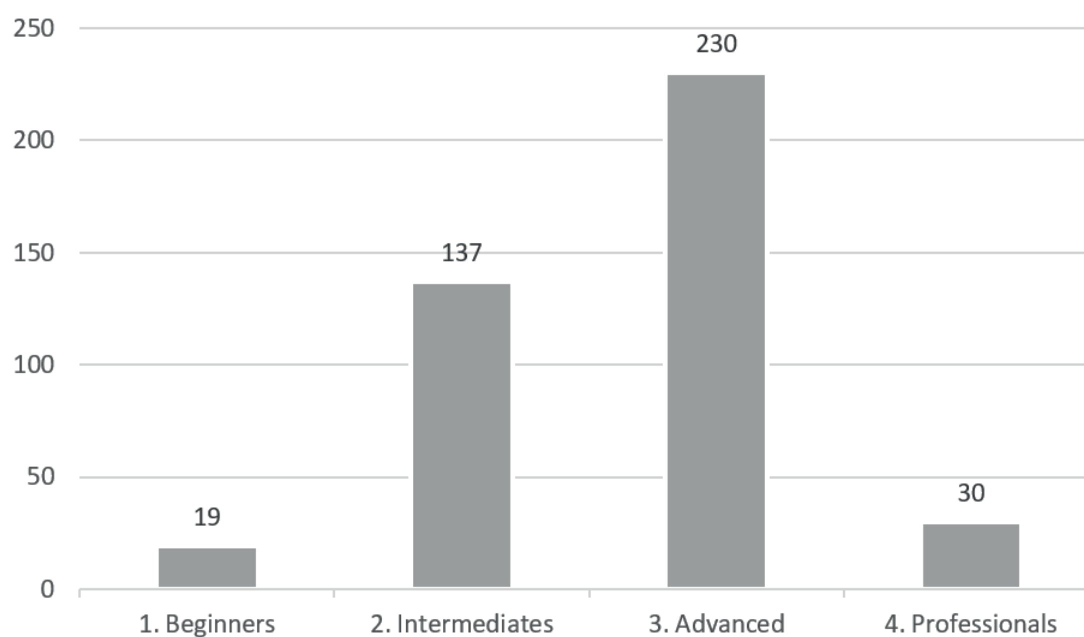

Figure 2. Distribution of patients included in the study according to their self-assessed skill level

Table 1. Type of injuries and their amount.

Type of injuries / Amount	Overall injuries	Soft tissue injuries	Bone tissue injuries
Knee injuries	91	76	15
Shoulder injuries	52	39	13
Wrist injuries	36	19	17
Hand or finger injuries	30	16	14
Forearm injuries	24	12	12
Upper arm injuries	17	6	9
Ankle injuries	15	11	4
Rib injuries	15	8	7
Foot injuries	15	2	13
Head injuries	14	10	4
Clavicle injuries	12	0	12
Shin injuries	12	6	6
Spinal injuries outside the neck	11	9	2
Hip injuries	9	8	0
Thigh injuries	8	6	2
Neck injuries	7	7	0

Table 2. Factors affecting injury – overall, multivariable analysis.

Variable	Odds Ratio (OR); CI 95%	"p" value
Age	1.03 (1.00–1.06)	0.059
Experience	**1.04 (1.01–1.07)**	**0.008**
Gender (male vs. female)	1.18 (0.69–2.03)	0.540
Body mass index	0.96 (0.89–1.03)	0.216
Freeriding	0.65 (0.38–1.09)	0.104
Skiing vs no-skiing	**1.93 (1.10–3.40)**	**0.022**
Endurance training in off-season	0.87 (0.41–1.90)	0.714
Strength training in off-season	**0.44 (0.22–0.87)**	**0.032**

Concerning bone structures injury risk, people who ski, were significantly more prone to bone structures injuries compared to snowboarders and people doing ski tours. Another risk factor was more experience. There were no protective factors detected. Detailed data was summarized in the Table 4.

Discussion

The most important results of this study are that more experience and skiing vs snowboarding or ski-touring were associated with higher risk of injury, while strength training in off-season was associated with lower risk of injury. Relevance of experience persisted in separate analysis of soft tissues and bony structures injuries. On the other hand, skiing was only a risk factor for bone structures injuries, while strength training was only a protective factor for soft tissues injuries. Possible explanations of above phenomena and comparison of analyzed factors are presented below.

Table 3. Factors affecting soft tissue injuries, multivariable analysis.

Variable	Odds Ratio (OR); CI 95%	"p" value
Age	1.03 (1.00–1.06)	0.067
Experience	**1.04 (1.01–1.07)**	**0.003**
Gender (male vs. female)	1.09 (0.63–1.89)	0.748
Body mass index	0.96 (0.90–1.03)	0.247
Freeriding	0.77 (0.46–1.29)	0.319
Skiing vs no-skiing	1.38 (0.78–2.43)	0.266
Endurance training in off-season	0.87 (0.42–1.81)	0.711
Strength training in off-season	**0.46 (0.23–0.91)**	**0.025**

Table 4. Factors affecting bone structures injuries, multivariable analysis.

Variable	Odds Ratio (OR); CI 95%	"p" value
Age	0.98 (0.94–1.01)	0.185
Experience	**1.05 (1.02–1.09)**	**0.003**
Gender (male vs. female)	1.23 (0.76–2.41)	0.283
Body mass index	1.00 (0.98–1.02)	0.659
Freeriding	0.88 (0.48–1.62)	0.687
Skiing vs no-skiing	**3.77 (1.92–7.42)**	**0.0001**
Endurance training in off-season	0.45 (0.19–1.09)	0.077
Strength training in off-season	0.75 (0.36–1.55)	0.441

Age & Experience

Among the participants of our study, the risk of injury was not affected by age, however it was positively associated with experience. Because of the varying ways that data on the age and experience of injured patients is presented and analyzed, it is difficult to draw definite conclusions about the effect on the overall risk of injury in winter sports (Davey *et al.,* 2019). Injury trends were reported to occur in a bimodal fashion, with increasing incidence of trauma observed among the very young and inexperienced skiers and the older more experienced skiers seeking challenges beyond their abilities (Meyers *et al.,* 2007). Some studies suggests that beginners have a higher risk of injury due to inexperience and improper equipment fitting (Bouter *et al.,* 1989; Ekeland *et al.,* 1993; Goulet *et al.,* 1999, 1999; Hagel, 2005; Kocher *et al.,* 1998; Meyers *et al.,* 2007). However, in the current study people below 18 years old were not included, and only 19 (4.57%) beginners were included.

Gender

In the current study, there was no gender difference in risk of injury. Some studies show that men are more likely to suffer from bone injuries (Burtscher *et al.,* 2008; Davey *et al.,* 2019; Davidson and Laliotis, 1996). It is most likely due to greater risk-taking behavior in men (Willick *et al.,* 2017). However, newer and more complex analyzes with a larger research group show that men are more likely to have overall injuries while women are more susceptible to soft tissue injuries, including knee ligament injuries (Lefevre *et al.,* 2013; Raschner *et al.,* 2012; Shea *et al.,* 2014). Another study (Kim *et al.,* 2012) found that injury rate among snowboarders was higher in female participants, which is different from other investigations.

Body mass index

In the literature there is an insufficient data associating BMI with the overall injuries of the skiers and snowboarders. According to our analysis BMI was not a significant risk factor. On contrary, in the study of Ruedl *et al.* who assessed injuries in female skiers, increased BMI was significant risk factor for skiing ACL injury in univariate analysis, while in multivariate analysis it was not significant (Ruedl *et al.*, 2011). Fakhry *et al.* reported BMI to be associated with an injury pattern of increased rates of extremity fractures and worsening outcomes in the general trauma setting (Fakhry *et al.*, 2021).

Freeriding

Results of our study indicate that skiers and snowboarders who freeride have no significant difference for having an injury overall. The study by Frühauf *et al.* analyzed injuries in group of freeriders, however the authors of the current study failed to find any publication comparing injury rate in winter sports participants performing vs. not performing freeride (Frühauf *et al.*, 2020). Study by Hasler *et al.* analyzed 117 snowboarders with traumatic brain injury (TBI). 82.9% of TBI occurred while riding on-slope and 5.1% off-piste (n = 6). Analyses comparing riders off-piste (freeriders) versus on-slope showed a significantly increased adjusted OR of 26.5 (p = 0.003) for sustaining a moderate-to-severe (TBI) among off-piste snowboarders (Hasler *et al.*, 2015).

Skiing vs snowboarding and ski-touring

In our study, skiers had higher overall and bone injury risk compared to snowboarders and people doing ski touring. This results is in agreement with the study of Wallner *et al.*, who reported less amount of severe injuries following interindividual collisions in snowboarders than skiers (Wallner *et al.*, 2022). In the study by Yoshimura *et al.*, snowboarders were almost twice as likely to require general anesthesia emergency surgery following winter sports injury. However, their study concerning trauma care patients and therefore it cannot be extrapolated on the whole winter sports participants population. (Yoshimura *et al.*, 2022). In the recent study of Huffman *et al.*, snowboarders were more prone to acute vertebral fractures than skiers. However, the authors reported significant decrease between 2000–2003 compared to 2016–2019 (Huffman *et al.*, 2022). This is in agreement with 18-year case control study by Kim *et al.*, who noted that the rate of injury in snowboarders to skiers were varying over time likely because of the newness of snowboarding and the majority of participants being beginners (Kim *et al.*, 2012).

Off-season training

Various training methods are proposed by different studies to prevent winter sports injuries. One of the methods are endurance training and strength training (Dem *et al.*, 2004; Hunter, 1999; Kocher *et al.*, 1998; Koehle *et al.*, 2002; Laskowski, 1999; Meyers *et al.*, 2007; Reider and Marshall, 1977; Steadman *et al.*, 1987). In spite of all the advice, there is not convincing evidence that off-season strength and endurance training can reduce the risk of winter sports injuries. In the current study group, endurance training was not a protective factor, while strength training was associated with reduced overall risk of injury and risk of soft tissues injury. Interestingly, there was no such association with bone structures injury. One of possible explanations is that in cases of bone structures injury the trauma was occurring with higher force and muscle strength was not as important as in lower-force soft tissues injuries. These results are in agreement with the 10-year longitudinal study by Raschner *et al.*, in which core strength was stated to be a critical factor in preventing injuries (Raschner *et al.*, 2012).

Limitations of the study

This study is retrospective in design, with all inherent limitations of that. What is more, it is based on a questionnaire survey and not a professional medical database. The number of included patients is relatively high, however in some subgroups it could be higher.

Nevertheless, this study has some strengths as well. Due to strict study criteria, people with injuries not related with winter sports, people with rheumatic and musculoskeletal diseases were excluded, eliminating potential confounders. What is more, data were analyzed by the means of logistic regression, allowing for assessment of simultaneous assessment of multiple variables on the injury risk.

Conclusion

In Polish population of winter sports participants, the most injured sites were the knee, shoulder and wrist. More experience and skiing were associated with higher risk of injury, while strength training in off-season was associated with lower risk of injury.

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REVIEW ARTICLE

WHAT IS THE IMPACT OF COLD WATER BATHING AND SWIMMING ON HUMAN HEALTH? LITERATURE REVIEW

JAKI JEST WPŁYW MORSOWANIA I PŁYWANIA W ZIMNEJ WODZIE NA ZDROWIE CZŁOWIEKA? PRZEGLĄD LITERATURY

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ABSTRACT
Introduction
Winter swimming has a long tradition that dates back to ancient times. In recent years, there has been an increase in interest in this activity in Poland and European countries.

Aim
The aim of this review is to present the positive and negative aspects of bathing and swimming in cold water.

Materials and methods
Our research involved freely accessible databases: PubMed, Google Scholar, ScienceDirect, using keywords such as: winter swimming, cold water bathing, hypothermia.

Results
The effect of increasing human immunity as a result of winter swimming is possible. Swimming has a slight influence on the fluctuations of hormone levels. The effect of cold water swimming on the circulatory system may be positive or negative, depending on the level of adaptation of the practitioner.

Conclusions
Regular cold water swimming by adapted individuals may have potential health benefits. There are health risks associated with such baths for unadapted people. The impact of cold water bathing and winter swimming should be further investigated.

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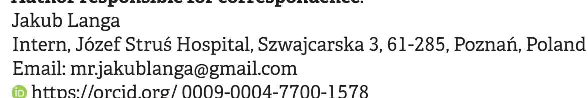
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STRESZCZENIE

Wstęp

Morsowanie to coraz bardziej popularny sposób na spędzanie wolnego czasu. Polega ono na kąpieli w jeziorze, rzece, morzu czy basenie, głównie w czasie okresu zimowego w zimniejszych i polarnych regionach.

Cel

Celem pracy przeglądowej jest zaprezentowanie pozytywnego i negatywnego wpływu morsowania i pływania w zimnej wodzie na funkcjonowanie szeregu układów i narządów.

Materiał i metody

Do naszych badań wykorzystaliśmy ogólnodostępne bazy danych: PubMed, Google Scholar, ScienceDirect, wykorzystując takie słowa kluczowe jak: winter swimming, cold water bathing, hypothermia.

Wyniki

Efekt zwiększenia odporności człowieka w wyniku morsowania jest możliwy. Morsowanie wpływa nieznacznie na wahanie poziomu hormonów. Wpływ pływania zimą na układ krążenia może być pozytywny lub negatywny, w zależności od stopnia przystosowania ćwiczącego.

Wnioski

Regularne pływanie w zimnej wodzie przez osoby przystosowane może przynosić potencjalne korzyści zdrowotne. U osób nieprzystosowanych istnieje ryzyko zdrowotne związane z takimi kąpielami. Wpływ morsowania i pływania w zimnej wodzie powinien być dalej zbadany.

Słowa kluczowe: pływanie w zimnej wodzie, morsowanie, hipotermia

Introduction

Winter swimming and bathing are increasingly popular ways of spending free time. It involves swimming in a lake, river, sea or swimming pool, mainly during winter, in colder and polar regions. As a result, the entire body is exposed to the stressful effects of cold water, usually below 5°C (Lubkowska *et al.*, 2013) (Knechtle *et al.*, 2020). Initially popular mainly in Scandinavian countries, it now arouses interest among people all over the world (Knechtle *et al.*, 2020). Since 2020, we have noticed an increase in interest in this form of spending time (Kaniewska 2021). Popular opinion holds that this type of activity has a positive impact on the functioning of the body. Many scientific studies also suggest that swimming in cold water brings health benefits (Gibas-Dorna *et al.*, 2016), positively influencing, among others: on glucose and insulin metabolism, the immune system (Janský *et al.*, 1996), the hematopoietic system (Checinska-Maciejewska 2019) and the cardiovascular system (Manolis *et al.*, 2019).

Aim

The review aims to gather available data and summarize it to show the researched effects of cold water swimming and bathing on specific aspects of human health.

Material and methods

Our research involved freely accessible databases: PubMed, Google Scholar, ScienceDirect, using keywords such as: winter swimming, cold water bathing, hypothermia.

Results

Historical outline

The beginnings of the use of cold baths in medicine date back to around 2500 BC, when the inhabitants of ancient Egypt immersed their bodies in cool water for health purposes. Over time, for ancient peoples, bathing took on the form of an important spiritual rite, as well as one of the elements of social life, which contributed to the construction of widely accessible public baths by the citizens of ancient Rome (Wesołowski *et al.,* 2013). In 377 BC, Hippocrates described the effects of cold and the indications and contraindications for its use, according to which he recommended the use of low temperatures to reduce swelling, bleeding and pain (Tipton *et al.,* 2017). Methods of treating patients using low temperatures were used by Józef Strus, physician to King Sigismund Augustus. In 1578, doctor Wojciech Oczko published bathing regulations as well as indications and contraindications for their use in the treatise "Cieplice" (Wesołowski *et al.,* 2013). In 1808, the first seaside swimming pool was created in Poland in Brzeźno, which was open in the winter season. Nowadays cold baths have become more and more popular every year, which resulted in the creation of clubs bringing together enthusiasts of this form of group activity, practiced from autumn to spring. The oldest of them – the Gdańsk Walrus Club – was established in 1975, and since then over 100 clubs have been established throughout the country (Kaniewska *et al.,* 2021). The Polish name "morsowanie" as a term for short-term, cold baths in water in the open air comes from walruses, animals inhabiting the icy waters of the Arctic. In Russia, as in Poland, winter bathing enthusiasts are called walruses, in Finland seals, and in the United States polar bears (O morsach i morsowaniu. Obcy język polski 2020). The rapid increase in the popularity of winter swimming in Poland in recent years contributed to breaking the Guinness record for the largest number of people taking part in winter swimming at the same time 1.799 participants during the International Walrus Rally in Mielno in 2015 (Wesołowski *et al.,* 2013).

Impact on hematological and biochemical parameters of blood serum

Cold water swimming has a significant impact on the values of selected hematological parameters. The authors of one article noted that seven months of regular cold water swimming during the winter season results in increased serum EPO concentrations (Checinska-Maciejewska *et al.,* 2019) due to adaptive changes in response to transient hypoxia in the body, induced by reduced blood flow through the skin and kidneys, which is maintained a few minutes after immersion (Buemi *et al.,* 2010). Women are more susceptible to changes in serum EPO concentration (Checinska-Maciejewska *et al.,* 2019) due to the fact that the female body cools down more quickly (Gleyzer *et al.,* 2005). The previously described increase in EPO concentration due to cold stimulation leads to the stimulation of the hematopoiesis process. In people practicing cold-water swimming for half a year, blood counts showed increased concentrations of hemoglobin, hematocrit, erythrocytes, MCHC, MCV, MCH and decreased levels of platelets (Teległów *et al.,* 2015), with significant changes in platelet concentrations occurring mainly in women (Checinska-Maciejewska *et al.,* 2019). The described changes are also intensified by reduced plasma volume resulting from increased diuresis (Stocks *et al.,* 2004) and fluid shift due to increased sympathetic activity of the nervous system in the body's response to cold (Lubkowska *et al.,* 2013).

Subsequent authors noticed that regular exposure of the body to low temperatures in "walruses" also affects the immune system (Missau *et al.,* 2018), which is reflected in a decrease in WBC values and the levels of IgG, IgA and IgM immunoglobulins (Lubkowska *et al.,* 2013).

A case study by authors from Krakow showed that winter swimming may have an impact on laboratory results in the kidney

and liver profile, where after one 53-year-old swimmer left the water, a slight increase in AST, LDH and slight fluctuations in the level of electrolytes in the blood serum were observed – a decrease in the concentration of sodium cations and chloride anions and reduced urea concentration, suggesting that winter swimming may indicate the presence of other health problems of the swimmer (Ptaszek *et al.,* 2019).

Cold baths may also have a beneficial effect on cardiovascular risk – they cause a decrease in TG levels, homocysteine concentrations, and a lower Apo-B/ApoA-I ratio during the swimming season. The authors note, however, that the beneficial effect of cold bathing on cardiovascular risk factors may be gender-dependent; further research is therefore needed to draw accurate conclusions (Checinska-Maciejewska *et al.,* 2017).

Impact on the body's immunity and oxidative stress

If swimming in cold water has a positive effect on the functioning of the immune system, there should be noticeable changes in immune markers and health should improve during the swimming period. People bathing in cold waters reported fewer and less severe upper respiratory tract infections (URTI) compared to pool swimmers (Esperland *et al.,* 2022). This effect has not been precisely measured (Collier *et al.,* 2021). One study (Lombardi *et al.,* 2011) on a group of fifteen who attempted to swim 150 m in water at a temperature of 6 degrees Celsius may indicate a potential cause of such a phenomenon – the number of red blood cells, white blood cells and platelets increased significantly compared to the state before swimming. There was also a strong increase in the total number of neutrophils, lymphocytes and monocytes. Another study of ten people tried to measure the effect of winter swimming (three times a week for six weeks) on some components of the immune system and showed a small but significant increase in the proportion of monocytes and lymphocytes and increased TNF-α concentrations. An increase in plasma concentrations of some acute phase proteins, such as haptoglobin and hemopexin, was also observed. After 6 weeks of repeated immersions, an increase in the concentration of IL-6 in plasma and the total number of T lymphocytes (CD3), T helper lymphocytes (CD4), suppressor T lymphocytes (CD8), activated T and B lymphocytes (HLA-DR) was observed, and a decrease in the concentration was observed. alpha 1-antitrypsin in plasma. However, the researchers pointed out that the clinical significance of these observations remains to be clarified (Janský *et al.,* 1996).

Several studies have also tried to detect the effect of winter swimming on oxidative stress mechanisms (Lubkowska *et al.,* 2013) (Siems *et al.,* 1999) (Lubkowska *et al.,* 2019). Studies on rats immersed daily in water at a temperature of 5 degrees Celsius for several weeks have shown that females are better able to adapt to cold temperatures than males, as shown by an increase in the activity of erythrocyte superoxide dismutase (SOD) and the concentration of glutathione (GSH) in order to restoring the body's pro-oxidant balance (Lubkowska *et al.,* 2019). The study of 36 venous blood samples from people exposed to cold water baths compared to 40 people who had never practiced winter swimming suggests similar effects also in humans (Siems *et al.*, 1999).

Impact on hormonal balance

The reaction of the hormonal axes, when bathing at low temperatures, also seems interesting (Briganti *et al.,* 2023). One study examined the effect of long-term exposure to low temperatures on the concentration of adrenocorticotropic hormone (ACTH), cortisol, adrenaline and norepinephrine (Leppäluoto *et al.,* 2008) in the blood. The results showed that exposure to low temperatures did not suddenly disturb the functioning of the pituitary-hypothalamic axis – only a slight decrease in ACTH levels was noted, which may have resulted from the body's habituation. Plasma adrenaline levels also remained

unchanged relative to the control group. However, researchers found an increase in norepinephrine concentration each time after exposure to low temperature.

In another study (Smolander *et al.,* 2009), the researchers decided to check how cool baths affect the concentration of prolactin, thyroid hormones, thyroid-stimulating hormones and growth hormone (GH) in a group of six healthy women. During the 12-week study, only slight fluctuations in thyroid-stimulating hormones were observed, but they did not exceed normal values for a healthy population. No changes in plasma concentrations of other tested hormones were observed. On this basis, the researchers concluded that regular winter swimming does not cause any changes in the levels of the tested hormones in the blood of healthy women.

In turn, in another study on a group of 15 middle-aged people staying in cold water for 15 minutes regularly for 6 months, an increase in the level of parathyroid hormone (PTH), thyrotropin (thyroid-stimulating hormone – TSH) and a decrease in triiodothyronine (T3) and thyroxine (T4). The increase in PTH concentration also correlated with a decrease in systemic calcium concentration and an increase in phosphorus levels (Kovaničová *et al.,* 2020).

Cold water swimming may have a positive effect on insulin metabolism. The effect seems to be sex-specific (Gibas-Dorna *et al.,* 2016) (Gibas-Dorna *et al.,* 2016). For female and swimmers with lower body fat percentage, there was an increased insulin sensitivity as well as a reduction in insulin secretion and resistance in a six month field study (Kaniewska *et al.,* 2021).

There is a study of thermogenic brown adipose tissue (BAT) (Søberg *et al.,* 2021) (in experienced winter-swimming men performing brief dips in cold water with hot sauna sessions 2–3 times per week. The data suggests a lower thermal comfort state in the winter swimmers compared with controls. In response to cold, there was observed greater increases in cold-induced thermogenesis and supraclavicular skin temperature in the winter swimmers, suggesting both heat and cold acclimation in winter swimmers, and showcase winter swimming as a potential strategy for increasing energy expenditure.

Effects on the circulatory system

One of the main indicators of the condition of the cardiovascular system is blood pressure (BP). When it is too high, it is one of the most important factors increasing the risk of developing cardiovascular diseases. For these reasons, BP is a frequent target for research on the impact of winter swimming on the human body. One study conducted on a group of long-distance swimmers showed a significant decrease in diastolic blood pressure (DBP) after a few days of practicing this form of activity (Huttunen *et al.,* 2000). Another study conducted on seasonal winter swimmers showed that DBP increased slightly during bathing, but returned to normal four minutes after surfacing (Zenner *et al.,* 1980).

The ratio of lipoprotein B to lipoprotein A is reflected in the level of LDL and HDL. However, in a comparative study on a group of ten adapted winter swimmers and sixteen unadapted swimmers, although a reduced ratio of lipoprotein B to lipoprotein A was observed in the first of these groups, no statistically significant changes were noted in the values of other lipoprotein parameters (Kralova Lesna *et al.,* 2015).

Another important parameter are troponins, the level of which was significantly increased in swimmers covering distances from 500 to 1000 meters in winter competitions. The peak value of high-sensitivity troponins (hsTnI) occurred within 2 hours after the end of exercise. The concentration of the N-terminal fragment of brain natriuretic peptide type B (NT-proBNP) was also measured as a marker of heart failure. However, no statistically significant changes or connections between hsTnI and NT-proBNP levels were demonstrated (Broz *et al.,* 2017).

There have also been studies examining the impact of cold baths on the occurrence of arrhythmia. At the moment of immersion,

an "autonomous conflict" develops. Both the sympathetic and parasympathetic nervous systems are then activated. This results in the simultaneous induction of tachycardia or bradycardia. Therefore, the risk of arrhythmia increases and, in people with additional burden, it may even result in death. (Kovaničová *et al.*, 2020) (Shattock *et al.*, 2012) (Ishikawa *et al.*, 1992) (Wolf *et al.*, 1965).

Conclusions

Regular bathing in cold water may increase the concentration of erythropoietin and stimulate the hematopoiesis process, which is reflected in blood morphology parameters, mainly in women. Moreover, tests of other biochemical parameters in blood serum showed a slight anti-inflammatory effect and a beneficial effect on cardiovascular risk.

Tests of the levels of hormones: prolactin, cortisol, adrenaline, noradrenaline, triiodothyronine, thyroxine, under the influence of 12 weeks of observations, did not show any significant fluctuations. The researchers only observed increased levels of plasma norepinephrine concentration after exposure to low temperatures.

Cold water swimming may affect the number of white and red blood cells, but its direct impact on the increase in immunity and oxidative stress is a controversial issue that should be subjected to further research.

Bathing in cold water may also be important for the circulatory system. Practicing winter swimming by experienced people may cause positive changes, such as lowering blood pressure or lowering the ratio of lipoprotein B to lipoprotein A. In turn, the level of hsTnI may increase, as well as the risk of developing arrhythmia.

Summarizing the collected literature, it can be concluded that winter swimming may have many health benefits, but further research is necessary, especially on numerous groups, to clearly assess the impact of this activity on the human body.

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REVIEW ARTICLE

POSTERIOR INSTABILITY OF THE SHOULDER JOINT

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ABSTRACT
Posterior instability of the shoulder joint, although less common than its anterior counterpart, presents a significant challenge in diagnosis and management. This article delves into the anatomy, epidemiology, pathophysiology, examination techniques, imaging diagnosis, and treatment modalities associated with this condition. Understanding the shoulder's intricate structure, which involves both static and dynamic stabilizers, is crucial for comprehending the mechanisms leading to instability. Clinical evaluation, encompassing visual inspection, palpation, and specialized tests like the Kim and Jerk tests, aids in identifying posterior instability. Imaging techniques, including radiographs, CT scans, and MRIs, play a pivotal role in visualizing dislocations, bone defects, and soft tissue pathologies, thereby facilitating precise treatment planning. The treatment approach typically involves conservative measures, with surgical intervention reserved for severe cases or persistent instability. Awareness of the condition's rarity, coupled with a comprehensive diagnostic and treatment approach, ensures optimal outcomes and prevents progression to advanced stages.

Keywords: posterior instability, shoulder, glenohumeral ligaments, Jerk Test

STRESZCZENIE
Niestabilność tylna stawu ramiennego, choć występuje rzadziej niż jej przedni odpowiednik, stanowi poważne wyzwanie w diagnostyce i leczeniu. Niniejszy artykuł przedstawia anatomię, epidemiologię, patofizjologię, techniki badania, diagnostykę obrazową i metody leczenia związane z tym schorzeniem. Zrozumienie skomplikowanej struktury barku, która obejmuje zarówno statyczne, jak i dynamiczne stabilizatory, ma kluczowe znaczenie dla zrozumienia mechanizmów prowadzących do niestabilności. Ocena kliniczna, obejmująca oględziny, badanie palpacyjne i specjalistyczne testy, takie jak testy Kima i Jerk, pomaga w identyfikacji niestabilności tylnej. Techniki obrazowania, w tym zdjęcia radiologiczne, tomografia komputerowa i rezonans magnetyczny, odgrywają kluczową rolę w wizualizacji przemieszczeń, uszkodzeń kości i patologii tkanek miękkich, ułatwiając w ten sposób precyzyjne planowanie terapii. Metody leczenia zazwyczaj obejmują środki zachowawcze, z interwencją chirurgiczną zarezerwowaną dla ciężkich przypadków lub utrzymującej się niestabilności. Mając świadomość rzadkości występowania tego schorzenia, w połączeniu z kompleksowym podejściem diagnostycznym i terapeutycznym, zapewnia się optymalne rezultaty i zapobiega progresji do zaawansowanych stadiów.

Słowa kluczowe: niestabilność tylna, staw ramienny, więzadła obrąbkowo-ramienne, Jerk Test.

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Introduction

Posterior instability of the shoulder joint arises from micro/macro injuries and developmental abnormalities. It involves the inability to keep the head of the humerus in the acetabulum and is characterized by recurrent dislocations of the shoulder joint. Posterior instability is far less common than anterior instability, so this pathology is very often overlooked, but accurate diagnosis is able to help us correctly differentiate this pathology at an early stage (Song *et al.,* 2015) (Provencher *et al.,* 2011). This article aims to introduce how important the proper diagnosis and management of the patient when this pathology is found is in the diagnosis of posterior instability.

Anatomy

The shoulder joint is a ball-and-socket joint (McCausland *et al.,* 2023). The articular head is formed by the head of the humerus, which has a spherical shape and diameter of about 43 mm. It is positioned in 20° retroversion to the transepicondylar axis and its articular surface is inclined upward by 130° compared to the humeral shaft. The acetabulum is composed of the glenoid cavity of the scapula and the glenoid labrum attached to the edges of the glenoid cavity. Due to the presence of glenoid labrum, the surface area of the acetabulum is enlarged by 50%. The acetabulum is a pear shaped, inclined 5° upward, and is positioned mostly in 5° retroversion to the axis of the scapula. One-third of the head of the humerus connects to the acetabulum, which allows the shoulder joint to have the greatest range of motion among joints in the entire body (Cowan *et al.,* 2023). The stability of this joint is a result of the balance between static stabilizers (glenoid labrum, ligaments, negative intra-articular pressure) and dynamic stabilizers (rotator cuff, long head of biceps brachii muscle, deltoid muscle and periscapular muscles). The joint capsule consists of fibrous membrane as well as synovial membrane, where they attach to the anatomical neck of the humerus, and within the acetabulum to the outer edge of the glenoid labrum (Doehrmann *et al.,* 2023).

The ligaments of the shoulder joint, namely the coracohumeral ligament, extend from the base and lateral edge of the coracoid process to the humeral tuberosities. The glenohumeral ligaments are thickenings of the fibrous capsule of the joint. They attach just like the fibrous capsule membrane of the joint. SGHL – superior glenohumeral ligament is located together with the coracohumeral ligament in the rotator cuff interval, which plays a minor role in the posterior stabilization of the shoulder joint (Mologne *et al.,* 2008). There is also MGHL – medial glenohumeral ligament and IGHL – inferior glenohumeral ligament, which consists of an anterior band and a posterior band (Figure 1). The posterior band, along with the posterior portion of the joint capsule and the glenoid cavity, are the most important static stabilizers of the posterior aspect of the shoulder joint (O'Brien *et al.*, 1995) (Millett *et al.*, 2006).

The dynamic stabilizers which are the rotator cuff consisting of the supraspinatus, subscapularis, obturator minor and subscapularis muscles along with the long head of the biceps muscle and deltoid muscle have a key function in stabilizing the shoulder joint. The contraction of these muscles presses the joint head against the acetabulum, which increases stabilization, and more force is needed for the displacement of the humeral head to occur (Pagnani *et al.,* 1994). The subscapularis muscle is primarily responsible for posterior stabilization (Kido *et al.,* 2003).

Epidemiology

Posterior instability is relatively rare and accounts for about 10% of shoulder instability cases (Song *et al.,* 2015). Anterior instability is much more frequent because it occurs 16–20 times more often (Robinson *et al.,* 2011). Due to the rarity of this condition, it is easy to overlook. It mainly affects athletes such as weightlifters, powerlifters, overhead athletes and military personnel.

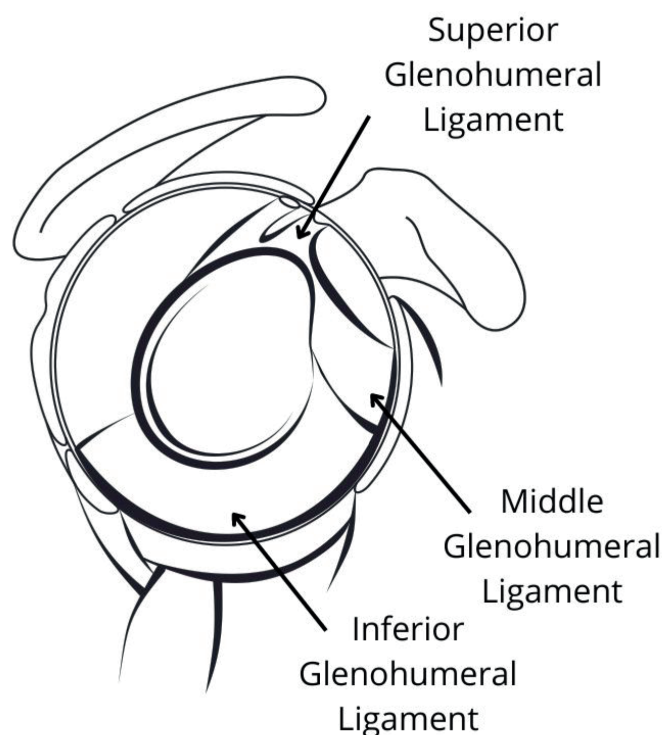

Figure 1. MGHL – medial glenohumeral ligament and IGHL – inferior glenohumeral ligament, which consists of an anterior band and a posterior band

Pathophysiology

We can distinguish two main mechanisms leading to instability. Acute trauma and microtrauma. In the case of acute trauma, significant force is required, such as in a motorcycle accident, during a convulsion or in cases of electrocution (Provencher *et al.*, 2011). In the microtrauma, repetitive activities that cause microdamage to the posterior part of the joint are performed, such as push-ups, bench pressing, or shooting a gun (Cho *et al.*, 2012). The arm is then positioned in flexion, adduction and internal rotation. The effect of repeated activities is stretching of the posterior stabilizing structures and damage to the glenoid labrum. Isolated damage to the posterior portion of the glenoid labrum is called Reverse Bankart Lesion. When, in addition to the glenoid labrum, a bony fragment from the posterior part of the joint acetabulum is detached, it is called Reverse Bony Bankart Lesion (Figure 2). An incomplete, hidden detachment of the posterolateral labrum is Kim Lesion (Kim *et al.*, 2004). Often, when significant forces are applied in a dislocation, a Hill-Sachs Fracture, which is a fracture of the anteromedial portion of the humeral head, occurs (Bock *et al.*, 2007).

Predisposing factors for posterior instability are: Excessive capsular laxity, and large capsular recess (Bigliani *et al.*, 1995). The key element for stabilization, however, is proper alignment of the head with the articular acetabulum, and proper securing of the two through muscle forces (Lazarus *et al.*, 1996).

Examination

The patient describes pain located deep in the back of the shoulder, may be accompanied by clicking or popping and deterioration of arm strength. The patient should be asked if they have any conditions that cause increased tissue flaccidity such as Marfan's disease (Frank *et al.*, 2017). A physical examination should be performed comparatively with the healthy side starting with a visual inspection, where in about 60% of cases a depression is present on the posteromedial aspect of the arm. Palpation tenderness in the posterior

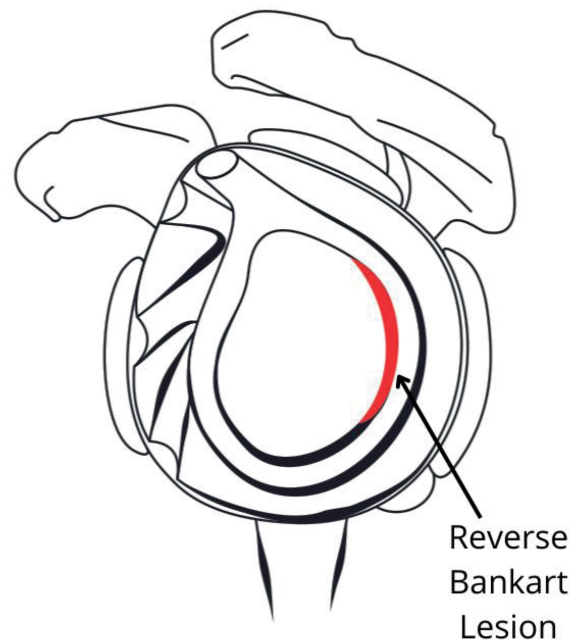

Figure 2. Reverse Bony Bankart Lesion

shoulder may be present, as well as scapular dyskinesis, or abnormal scapular mobility and alignment (Brelin *et al.,* 2017).

A test to detect posterior instability is the Kim test. The patient is in a sitting position, abducts the shoulder and flexes the elbow joint to 90˚. The clinician then presses the abducted arm against the joint, and grabs the elbow with one hand and the deltoid muscle area with the other. The arm is lifted upward 45˚ while the proximal end is pressed downward. Painfulness while performing this test indicates posterior instability of the shoulder joint (Kim *et al.,* 2005) (Figure 4).

Another provocative test for posterior instability is the Jerk Test. The examiner stands next to the patient, holding the patient's elbow with one hand and the distal aspect of the clavicle and the spine of the scapula with the other. Physician abducts the arm and flexes at the elbow to 90˚, pressing the arm against the joint and rotating internally. This test can be considered positive when there is a characteristic click along with pain during horizontal adduction of the arm (Kim *et al.,* 2005) (Figure 3).

Imaging diagnosis

Plain radiographs in patients with posterior instability are recommended in anteroposterior, lateral and axillary projections (Williams *et al.,* 2007). It can visualize posterior dislocation, bone defects, or Hill-Sachs lesion. If the radiograph is not sufficient to visualize the bony structures, computed tomography should be used (Van Tongel *et al.,* 2010). In order to better visualize the soft structures of the joint, MRI is used, which can visualize the loss of the glenoid labrum, pathologies of the joint capsule, posterior humeral avulsion of the glenohumeral ligament and posterior labrum periosteal sleeve avulsion, or Kim lesion (Kim *et al.,* 2004) (Bey *et al.,* 2005) (Yu *et al.,* 2002).

Treatment

When planning the management of a patient with posterior instability of the shoulder, there are many factors to consider, such as reducing pain, improving mobility and preventing possible recurrence (Frank *et al.,* 2017). A conservative approach of at least 6 months is typically the first line of treatment for patients with posterior instability, with outcomes dependent on the underlying

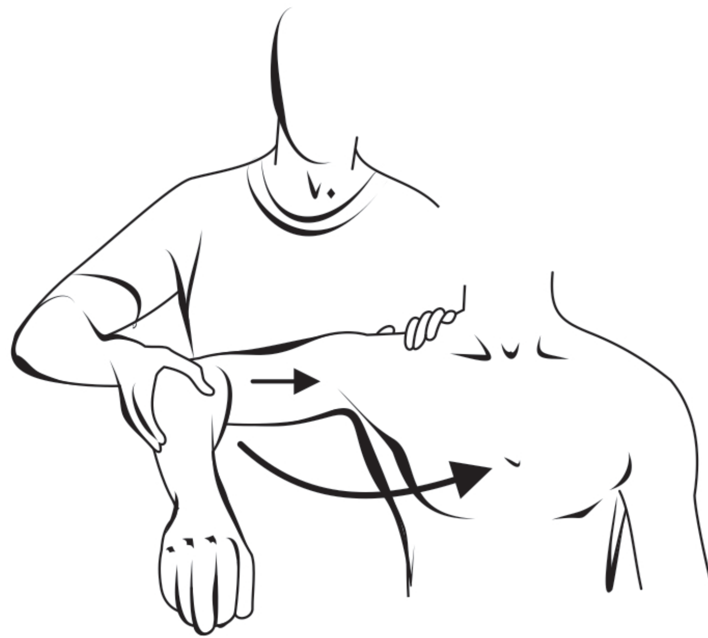

Figure 3. Jerk Test – provocative test for posterior instability

Figure 4. Kim test – test to detect posterior instability

etiology [2] (Frank *et al.*, 2017) (Brelin *et al.*, 2017) (Antoniou *et al.*, 2001) (Tannenbaum *et al.*, 2013) (Robinson *et al.*, 2005).

In the treatment of posterior instability of the shoulder joint, there are two treatment options. One is non-operative treatment, which in most cases is used for non-traumatic shoulder joint instability, or joint limp (a state of joint hypermobility in which the mobility of the joint is above accepted norms). The group of non-traumatic instability also includes connective tissue diseases and anatomical variants in the development of bones and joint surfaces. Non-operative treatment primarily relies on conservative methods and is based on: rehabilitation, changes in physical activity and patient education (Doehrmann *et al.,* 2023).

For more serious injuries localized to the shoulder girdle such as: avulsion of posterior band of IGHL, rupture of any of the tendons of the rotator cone muscles, or in patients who

experience recurrent shoulder pain, instability or functional limitations after conservative treatment of 3 to 6 months, surgical treatment is necessary (Provencher *et al.*, 2011) (Doehrmann et a., 2023) (Frank *et al.*, 2017) (Kim *et al.*, 2005) (Antoniou *et al.*, 2001).

Treatments for bone pathology are performed open, while treatments for soft tissue pathology are performed arthroscopically. There is no consensus in the literature on the specific indications for each procedure, so doctors must consider the optimal treatment for the patient on a case-by-case basis (Doehrmann *et al.*, 2023). Although the results are very good for open treatment of anterior instability, the failure rate for open treatment of posterior instability is as high as 30–70% (Provencher *et al.*, 2011). On the other hand, if the pathology in the shoulder bone is small, arthroscopic procedures are used to treat posterior instability, due to their less invasive nature, the ability to view the entire rim and treat concomitant pathologies, and the faster recovery of the patient (Brelin *et al.*, 2017) (Frank *et al.*, 2017). During the arthroscopic procedure, the patient lies on his side. Standard surgical anchors are used to repair the rim, using 3 to 4 portals to facilitate removal and placement of sutures. A diagnostic arthroscopy is performed through the posterior portal, an anteroposterior portal, which is located at the top of the rotator interval to help evaluate the rim damage, and a posterior portal at 7 o'clock located 2 cm laterally and 1 cm anteriorly from the original posterior portal, used to place sutures in the posterior portion of the acetabulum.For isolated posterior capsular and labral pathology, three to four suture anchors spaced about 5 mm apart on the acetabulum are usually sufficient. Regardless of the form of treatment, physiotherapy is an essential part of recovery (Provencher *et al.*, 2011) (Frank *et al.*, 2017) (Brelin *et al.*, 2017).

Rehabilitation

An important part of the rehabilitation process is strengthening the surrounding muscle group to produce additional stabilization in the shoulder joint. Rehabilitation should focus on proprioceptive exercises and strengthening the dynamic stabilizers of the shoulder, particularly the subscapularis. Scapulothoracic mechanics should be evaluated, as dysfunction can be a source of posterior shoulder pain (Brelin *et al.*, 2017) (Doehrmann *et al.*, 2023). Postoperative care of a patient with shoulder joint instability consists of immobilizing the shoulder in a shoulder brace, in such a way as not to stress the posterior shoulder joint muscle group. It is recommended that the patient have the shoulder joint immobilized for no less than 4 weeks. At first, the patient is encouraged to do gentle exercises focusing on the wrist and elbow joint. Then, after about 2 weeks, exercises that activate the rotator cone and shoulder joint are implemented (Provencher *et al.*, 2011) (Brelin *et al.*, 2017) (Doehrmann *et al.*, 2023).

After about 2 to 3 months after surgery, strengthening exercises should also be included. Return to sports is individually interpreted for each case, noting that the patient must achieve 80% of the strength of a healthy shoulder. In order for rehabilitation to be effective, it is extremely important from the very beginning of rehabilitation to involve both the patient and the therapist (Bäcker *et al.*, 2018) (Bradley *et al.*, 2013).

Conclusion

Posterior instability of the shoulder joint is an uncommon condition, and is therefore more difficult to diagnose than injuries that occur more frequently. It is important to pay attention to the anatomical structure of the shoulder, and the pathophysiology, which will help understand the mechanism of injury. Symptoms of the condition, the performance of provocative tests, and imaging allow early detection of pathology as well as assessment of its severity. Treatment consists of conservative as well as surgical methods. However, unlike anterior instability, surgical methods in posterior instability are less

effective, which is why it is so important to correctly and quickly diagnose the disease in order to prevent its advanced stage.

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REVIEW ARTICLE

REHABILITATION AFTER HIP FRACTURE: A LITERATURE REVIEW

POSTĘPOWANIE REHABILITACYJNE PO ZŁAMANIU BIODRA – PRZEGLĄD LITERATURY

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ABSTRACT
Introduction
As a result of the aging population, hip fracture is emerging as a major medical, social and economical concern. A higher risk of fracture occurs in women of older age. Early surgery, preferably performed within 48 hours, is considered as the gold standard of treatment. Postoperative rehabilitation also has a significant role in patients' recovery.

Aim
The aim of this article is to compare the effectiveness of rehabilitation methods, such as physiotherapy and alternative interventions, provided after surgical treatment in patients with hip fracture.

Material and methods
Publications available on PubMed databases concerning the effectiveness of various rehabilitation methods after hip fracture were analyzed. In total, 15 works from 2018 to 2023 were included in the review.

Results
The review of clinical studies focused mainly on comparison of interdisciplinary home rehabilitation with conventional methods. Physiotherapy is particularly important in the recovery of patients after hip fracture. No significant difference was shown between the use of multidisciplinary therapy and classical physiotherapy in combination with in-hospital geriatric care.

Conclusions
The analyzed papers do not clearly indicate which form of rehabilitation should be considered most effective for elderly patients after hip fracture. Physiotherapy and Transcutaneous Electrical Nerve Stimulation play a crucial role in re-establishing mobility and improving quality of life. Chronically bed-ridden patients represent a group for whom the development of newer rehabilitation methods is particularly important. There is a need for further research into the methods and improvement of those currently in practice.

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STRESZCZENIE

Wstęp
W związku ze starzeniem się społeczeństwa złamanie biodra staje się jednym z głównych problemów medycznych, socjalnych i ekonomicznych. Zwiększone ryzyko złamania dotyczy kobiet w starszym wieku. Wczesne leczenie operacyjne, przeprowadzone przed upływem 48 godzin, uważa się za złoty standard. Rehabilitacja pooperacyjna również odgrywa znaczącą rolę w odzyskiwaniu sprawności przez pacjentów.

Cel
Celem niniejszego artykułu jest porównanie skuteczności metod rehabilitacyjnych, obejmujących fizjoterapię i sposoby alternatywne, stosowanych po leczeniu operacyjnym u pacjentów ze złamaniem biodra.

Materiał i metody
Analizie poddano dostępne w bazie PubMed publikacje dotyczące skuteczności różnych metod rehabilitacji po złamaniu biodra. Łącznie w przeglądzie uwzględniono 15 prac z lat 2018–2023.

Wyniki
Przegląd badań klinicznych koncentruje się głównie na porównaniu interdyscyplinarnej rehabilitacji domowej z metodami konwencjonalnymi. Fizjoterapia ma szczególne znaczenie w powrocie do zdrowia pacjentów po złamaniu biodra. Nie wykazano istotnej różnicy między stosowaniem terapii multidyscyplinarnej a fizjoterapii klasycznej w połączeniu ze szpitalną opieką geriatryczną.

Wnioski
Przeanalizowane prace nie wskazują jednoznacznie, która forma rehabilitacji powinna być uznana za najskuteczniejszą u starszych pacjentów. Fizjoterapia oraz przezskórna elektryczna stymulacja nerwów odgrywają istotną rolę w odzyskiwaniu sprawności ruchowej i poprawie jakości życia. Szczególnie ważną kwestię stanowi rozwój nowszych metod rehabilitacji ukierunkowanych na pacjentów przewlekle leżących. Ze względu na niejednoznaczne wyniki, niezbędne jest kontynuowanie badań nad nowymi metodami i udoskonalanie tych, które są obecnie stosowane.

Słowa kluczowe: złamanie szyjki kości udowej, rehabilitacja, ADL, fizjoterapia, TENS.

Introduction

Hip fracture is a common problem among the elderly people and thus has a major impact on length and quality of life for seniors. Worldwide, nearly 1.6 million hip fractures occur annually. However, there is a forecast that by 2050 this number may reach even 6.3 million (Liu *et al.,* 2021). According to the latest research, it is estimated that approximately 300.000 patients in the USA, 45.000 patients in Spain and 20.000 patients in Poland are treated for hip fractures annually (Tsitko *et al.,* 2023).

Hip fracture leads to serious consequences for the individual, as it can lead to disability and higher mortality. It also has a huge impact on the health service and society as a whole, mainly for economic and social reasons.

Mortality within one year after the fracture is 20–40%, predominantly in male patients (Tsitko *et al.*, 2023). About 33% of men and 22% of women suffering from a hip fracture are expected to die within 1 year (Li *et al.*, 2021).

Risk factors for hip fracture may be divided into modifiable and non-modifiable. Gender, age, low socio-economic status, family history of femoral neck fracture classify as non-modifiable risk factors. Women over the age of 85 are 10 times more likely to suffer a fracture than those aged 60–65. In contrast, modifiable risk factors for hip fracture include reduced bone mineral density, falls and chronic drug use. A bone mineral density with T-score less than −2.5 is associated with an increased risk of fractures. A lower T-score may be due to insufficient calcium and/or vitamin D supplementation as well as positive osteoporotic family history. Drugs that may increase the risk of falls include high levothyroxine doses, long-term therapy of proton pump inhibitors, benzodiazepines and selective serotonin reuptake inhibitors (Tsitko *et al.*, 2023).

Studies show that 30% of hip fractures occur in nursing homes, and this percentage is likely to increase due to the growing population over the age of 80 requiring constant care (Baek *et al.*, 2023).

There is a relationship between the risk of death after hip fracture and the general condition before the injury. The survival rate is negatively affected by: the presence of chronic diseases (e.g. renal and heart failures, diabetes, anemia, cancer), high ASA score, dementia and poor functional status before fracture (Xu *et al.*, 2019).

Due to the fact that the number of elderly patients with osteoporotic fractures is increasing, and this type of hip fracture seriously affects the quality of life and even survival rates of seniors, researchers are trying to find out which method of rehabilitation and treatment is the most effective. Early surgical treatment is recommended for hip fractures. Some guidelines advise surgery within 48 hours in order to decrease the risk of prolonged bed rest and mortality after operation (Zhu *et al.*, 2022). The difficulty in the treatment of such fractures is associated with the coexistence of multimorbidity and polypharmacy in elderly patients (Henriksen *et al.*, 2023). The role of rehabilitation in the postoperative period is also worth emphasizing (Zhu *et al.*, 2022).

This article aims to compare the effectiveness of rehabilitation methods and other interventions after surgical treatment, as well as to find the "gold standard".

Materials and methods

For the literature review, the PubMed database was searched for the period from 2018 to June 2023. Key words such as: hip fracture rehabilitation OR femoral neck fracture rehabilitation OR femoral trochanteric fracture rehabilitation were used. The "free full text", "Clinical Trial" and "Randomized Controlled Trial" filters were applied and 74 articles were identified. Only studies in English were selected. The papers that did not include methods of rehabilitation in patients with hip fracture were rejected. Finally, 15 articles matched the requirements.

Results

The results of literature review are presented in a table (Table 1).

Scales

Barthel Index for Activities of Daily Living (Barthel ADL) is used to assess and monitor the activity status of rehabilitated patients with chronic disabilities. The ability to perform basic activities of daily living, such as bathing, toileting, dressing, eating, continence, walking, grooming, and stair climbing is assessed. The score varies depending on whether the patient performs the activity independently or with the help of another person. Obtaining 0 points is tantamount to dependence in all of the assessed activities, and 100 points indicates full independence (Cech *et al.*, 2012).

Katz Index of Independence in Activities of Daily Living Scale (Katz ADL) assesses basic activities of daily living of older patients

Table 1. Results of the literature review.

Study	Patients	Age range (years)	Mean age (years) (* median age)	% Female	Duration of intervention	Rehabilitation methods	Results	Assessment tools
Taraldsen *et al.* (2019)	143 (IG-70, CG-73)	⩾70	83.4 (IG = 84.0 CG = 82.7)	69.20%	10 weeks	IG: routine treatment and rehabilitation + 20 sessions (10 weeks) structured, home exercise targeting gait and balance CG: routine treatment and rehabilitation	The intervention group improved over the control group in: Preferred GS: Mean change from T1 to T2: 0.09 m/s ($p = 0.001$) Mean change from T1 to T3: 0.07 m/s ($p < 0.009$) SL Mean change from T1 to T2: 3.85 cm ($p = 0.001$) Mean change from T1 to T3: 3.71 cm ($p = 0.002$) SPPB Mean change from T1 to T2: 1.4 points ($p < 0.001$) Mean change from T1 to T3: 1 points ($p = 0.017$) The intervention group improved over the control group in: ADL, upright time, cognitive function, health-related quality of life T1 – allocation (week 16–18) T2 – follow up (week 28–30) T3 – follow up (week 48–56)	electronic walkway, SPBB, IADL, MMSE, CDR, EQ-5D-3L
Karlsson *et al.* (2020a)	205 (IG-107, CG-98)	⩾70	82.9 (IG-83.2 CG-82.6)	71.70%	max. 10 weeks	IG: GIHR CG: in-hospital geriatric care	In terms of ADL no difference between IG and CG was found	BI, Katz ADL Index, ADL Staircase
Magaziner *et al.* (2019)	210 (IG-105, CG-105)	⩾60	80.8 (IG – 80.3, CG – 81.2)	76.70%	16 weeks	IG:included aerobic,strength,balance,and functional training. CG:TENS+active range-of-motion exercises	Community ambulation: IG – 22.9% CG – 17.8%	an ability to walk 300 m or more in 6 minutes
Berggren *et al.* (2019)	205 (IG – 107, CG – 98)	⩾70	82.9 (IG – 83.2, CG – 82.6)	71.70%	12 months	IG: GIHR CG: conventional geriatric care and rehabilitation	Complications: 53.8% (IG) vs 47.3% (CG) ($p = 0.443$) Falls: IG:43.4% (IG) vs 40.9% (CG) ($p = 0.828$) Readmission: 35.8% (IG) vs 29.0% (CG) ($p = 0.383$) Mediana całkowitej liczby dni spędzonej w szpitalu: 11.5 days (IG) vs 11.0 days (CG) ($p = 0.353$)	Complications, readmissions, and days of hospitalization were registered from patients' digital records and interviews

Table 1 (cont.) Results of the literature review.

Study	Patients	Age range (years)	Mean age (years) (* median age)	% Female	Duration of intervention	Rehabilitation methods	Results	Assessment tools
Soukkio *et al.* (2022)	121 (IG-61, CG-60)	⩾60	81 (IG-83, CG-80)	75.00%	12 months	IG – home-based supervised, progressive exercise program CG – conventional rehabilitation	Mean IADL score: 17.1 (IG) vs 17.4 (CG) Mean SPPB score: 3.9 (IG) vs 4.2 (CG) Mean Handgrip strength [kg]: 17.7 (IG) vs 20.8 (CG)	IADL score, SPPB score, Saehan dynamometer
Schemitsch *et al.* (2020)	332 (IG-243, CG-89)	55 to 94	79 in IG, 78 in CG*	68.70%	12 weeks	IG – romosozumab s.c. 70/140/210 mg 1st day/2/6/12 weeks after surgery CG – placebo	TUG score – no significant differences between IG and CG over weeks 6 to 20 ($p = 0.198$) The median time to radiographic evidence of healing – 16.6–16.9 weeks (IG), 16.4 weeks (CG) RUSH score – no significant differences between IG and CG	TUG score, time to radiographic evidence of healing, RUSH score
Howell *et al.* (2023)	32 (IG1-11, IG2-10, CG-11)	56 to 95	85 *	78.10%	IG1: 58 days, IG2: 77.5 days, CG: 80.5 days	IG1 – HIFE program IG2 – HIFE program + IMU CG – individually tailored standard rehabilitation	Balance (assessed by postural sway) – no significant improvement in any group. Improvement in all groups: functional balance ($p = 0.011–0.028$), activity of daily living ($p = 0.012–0.027$), HRQoL ($p = 0.017–0.028$). No significant differences between groups.	IMU, Functional Balance Test for Geriatric Patients (FBG), BI, EQ-5D
Ortiz-Piña *et al.* (2021)	71 (IG -35, CG-36)	⩾65	IG-75.86, CG-80.38	74.60%	12 weeks	IG – tele-rehabilitation (instructional videos, written instructions and caregivers supervision) CG – standard post-surgery rehabilitation	IG – higher FIM score, better TUG performance, No significant differences between IG and CG in SPPB.	FIM, TUG, SPPB
Kim *et al.* (2020)	34 (IG-17, CG-17)	n/a	IG: 48.82, CG: 51.82	23.50%	4 weeks	IG: 20 min of anti-gravity treadmill training five times per week, CG: 20 min of conservative rehabilitation five times per week	Significant improvement in isokinetic muscle strength, endurance of hip flexors and extensors in both groups ($p < 0.05$); No significant differences between IG and CG ($p > 0.05$) except for muscle strength of the hip extensor. Increase in activity of VL, VM, GM, and Gm muscles before and after the intervention ($p < 0.05$), Significant differences in muscle activities of GM ($d = 2.64$, $p < 0.001$) and Gm ($d = 2.59$, $p < 0.001$) between IG and CG.	Isokinetic Strength Measurement (The BTE Primus RS kinetic test evaluation device), Muscle Activities (four-channel electromyography (EMG) with Clinical Direct Transmission System(DTS)

Table 1. (cont). Results of the literature review.

Study	Patients	Age range (years)	Mean age (years) (* median age)	% Female	Duration of intervention	Rehabilitation methods	Results	Assessment tools
Karlsson *et al.* (2020b)	205 (IG- 107 [57 with demention, 50 without dementia], CG-98 [46 with dementia, 52 without dementia]	≥ 70	82.9	71.70%	max.10 weeks	IG – GIHR CG – In-hospital rehabilitation	Falls, postoperative hospitalization length, readmissions, mortality in 1st year after discharge, ambulance ability at 3 months and 1 year – no significant differences in dementia patients with GIHR and dementia patients in CG	postoperative length of stay, falls rate, readmissions rate, mortality in 1st year after discharge, walk ability in 3 and 12-months, BI, Katz ADL Index.
Elboim-Gabyzon *et al.* (2019)	41 (IG-23, CG-18)	> 50	79.3 (IG- 80.26, CG-78.06)	78.00%	5 days	IG – active TENS + rehabilitation CG – sham TENS + rehabilitation	IG – significantly higher reduction of pain intensity during walking ($p < 0.0011$), increase in ambulation distance and mobility level compared to CG. IG and CG – lesser intensity of pain at rest and night, no significant differences between groups.	intensity of pain NRS FAC; two-minute walk test)
Crotty *et al.* (2019)	240 (IG-121, CG-119)	≥ 70	88.6	74.20%	4 weeks	IG – postoperative rehabilitation program CG – usual care	IG – mobility improvement after 4 weeks compared to CG (NHLSD mean difference −1.9; $p = 0.0055$), no differences in quality of life. Quality of life increase in patients in IG was observed after 12 months (DEMQOL sum score mean difference = −7.4; $p = 0.0051$)	NHLSD, DEMQOL
Jinli-Guo *et al.* (2019)	79 (IG-39, CG- 40)	> 65	IG – 74.1, CG -75.1	59.50%	4 weeks	IG – upper-body yoga CG – abdominal breathing training	FVC% – 78.83% (IG) vs 72.20% (CG), $p = 0.016$ PCF – 216.16 L/min (IG) vs 194.95 L/min (CG), $p = 0.008$, BI – 70.77 (IG) vs. 65.75 (CG), $p = 0.019$	Spirometer tests, BI
Hulsbæk *et al.* (2019)	23 (IG -12, CG-11)	62–85	73.4	78.00%	12 weeks	IG – anabolic steroid (nandrolone decanoate), physiotherapy, protein-rich nutritional supplement CG – placebo, physiotherapy, protein-rich nutritional supplement	Non – significant difference in mean knee-extension strength in fractured leg – 0.61 Nm/kg (IG) vs 0.50 Nm/kg (CG)	Change in maximal isometric knee-extension strength (Nm/Kg) measured by a belt fixated handheld dynamometer
Sherrington *et al.* (2020)	336 (IG-168, CG-168)	59–99	78	76.00%	12 months	IG – individualized physiotherapist-prescribed program CG – usual care	Mean between-group difference – no statistically significant differences SPPB 0-3 scale – 0.08 points ($p = 0.08$, $n = 273$), AM-PAC 0-200 scale – 0.18 points ($p = 0.91$, $n = 270$), LLDI 0-200 scale – 1.37 points ($p = 0.49$, $n = 273$)	SPPB, AM-PAC, LLDI

Abbreviations: IG – intervention group; CG – control group; F – female; M – male; GS – gait speed; SL – step length; SPPB – Short Physical Performance Battery; I-ADL Basic and instrumental ADL; MMSE – Mini-Mental State Examination; CDR – Clinical Dementia Rating; EQ-5D-3L – EuroQol-5 dimension-3L; GIHR – Geriatric Interdisciplinary Home Rehabilitation; BI – Barthel Index; TENS – Transcutaneous Electrical Nerve Stimulation; TUG – Timed "Up & Go"; RUSH – Radiographic Union Scale for Hip; IMU – Inertial Measurement Unit; HRQoL – Health-related Quality of Life; FIM – Functional Independence Measure; VL – vastus lateralis; VM – vastus medialis; GM – gluteus maximus; Gm – gluteus medius; NRS – Numeric Rating Scale; FAC – Functional Ambulation Classification; NHLSD – Nursing Home Life-Space Diameter; DEMQOL – Dementia Quality of Life; FVC% – Forced Vital Capacity; PCF – Peak Cough Flow; AM-PAC – Activity Measure Post Acute Care; LLDI – Late Life Disability Instrument.

in the community and all care settings. It assesses the need for assistance in bathing, eating, dressing, transfer, toileting and continence (Arik *et al.*, 2015).

The Lawton Instrumental Activities of Daily Living (IADL) Scale takes into account the patient's capacity to perform eight activities, which include doing laundry, using the phone or handling finances. Obtaining a low score may indicate impairment in daily functioning and a need for a deeper evaluation (Graf *et al.*, 2008).

The Short Physical Performance Battery (SPPB) test is used to assess the physical activity of patients and allows the identification of people at particular risk of disability and difficulties in performing basic life activities. It evaluates three physical activities: maintaining balance in three positions, walking speed for a short distance at a normal pace and getting up five times from a chair without the help of the upper limbs. Each task is scored from 0 to 4 points, and in total the patient can score from 0 to 12 points. Obtaining 12 points indicates the best physical capacity. A low score on the test is a risk factor for future mobility problems, disability, hospitalization and death (Zasadzka *et al.*, 2013).

The Functional Balance Test for Geriatric Patients (FBG) assesses the patient's mobility during 4 activities, such as walking, turning, sitting and standing up as well as maintaining a standing position. Each activity is scored on a scale from 0 to 6, and the test's maximum number of points is 24 (Howell *et al.*, 2023).

The EuroQol 5 Dimension (EQ5D) consists of an assessment on a 5-point scale of 5 dimensions: mobility, anxiety or depression, self-care, pain or discomfort and usual activities. In addition, patients assess their health using the Visual Analogue Scale (VAS). The score on the scale ranges from 0 (death) to 1 (full health) and reflects the patient's state of health in comparison to the health status of the population of a specific region (Howell *et al.*, 2023).

The Timed Up and Go (TUG) test consists in measuring the time in which the patient gets up from the chair, walks a distance of 3 meters and then returns and sits back on the chair. The patient wears his comfortable shoes and may use walking aids. If the duration of these activities is greater than or equal to 13.5 seconds, this may indicate an increased fall risk (Barry *et al.*, 2014).

The Radiographic Union Score for Hip (RUSH) was designed to assess the radiographic fracture healing in femoral neck after surgeries. It is important to identify unhealed fractures to assess the need for further surgery in the patient (Frank *et al.*, 2016).

The Functional Independence Measure (FIM) assesses the need for help from others in performing specific 18 activities (such as self-care, continence, mobility, social cognition). Each activity is scored from 1 (complete dependence) to 7 (complete independence) points. The total score ranges from 18 points to 126 points (Ribeiro *et al.*, 2017).

Dementia Quality of Life Measure (DEMQOL) is a patient reported outcome measure, which is designed to enable the assessment of health-related quality of life of dementia patients. In DEMQOL 28 questions on health, well-being, daily activities, cognitive function, social contacts and self-perception are answered (Hendriks *et al.*, 2019).

Training programs

The Otago Exercise Program is usually performed at the patient's place of residence and its purpose is to prevent falls. It is based on walking as well as exercises to strengthen the muscles and improve balance (Martins *et al.*, 2018).

The High-Intensity Functional Exercise (HIFE) program is aimed at increasing the strength of lower limbs, as well as improving the balance and mobility (Sondell *et al.*, 2019).

Transcutaneous electrical nerve stimulation (TENS) is a method of pain relief involving the use of an electrical current in order to block the transmission of pain signals (Vance *et al.*, 2014).

Discussion

The study by Taraldsen *et al.* (2019) analyzed the effect of an additional 10 weeks of home rehabilitation on a patient's preferred gait speed. Gait speed was measured in m/s using an electronic walkway. Training program focused on muscle strength and included exercises such as lunges, sit-to-stand and box step-ups. The main outcome of the trial was gait speed. The provided intervention confirmed the effectiveness of the training plan and resulted in improvement of preferred gait speed in the trial group. In addition, the study showed no increase in total health care costs in the intervention group.

Karlsson *et al.* (2020a) studied the effect of early patient discharge along with geriatric interdisciplinary home rehabilitation (GIHR) on activities of daily living (ADL). The control group consisted of patients receiving rehabilitation in the hospital. The exercise plan for the study group was individualized and tailored to the needs of each patient. It included elements of the High-Intensity Functional Exercise (HIFE). The primary outcome, which was the independence of ADL, was measured using the ADL Barthel Index and ADL Staircase. In both study groups, patients regained independence in ADL after 3 and 12 months. No significant differences were observed between groups.

A trial conducted by Magaziner *et al.* (2019) tested the effects of 16 weeks of multicomponent physical therapy on the ability to walk 300 m or more in 6 minutes. The training in the study group included elements such as endurance, strength, balance and lower limb function. General home-based exercises and transcutaneous electrical nerve stimulation (TENS) were performed in the control group. The ability to walk in the community was regained by 22.9% and 17.8% of the study group and control group, respectively. The results represent no statistically significant difference in the intervention's effectiveness in the two groups.

Berggren *et al.* (2019) aimed to verify whether interdisciplinary home rehabilitation would reduce the number of complications, rehospitalization risk, falls risk and the total number of days of hospitalization compared to standard rehabilitation. The therapy included elements of the HIFE program. The ability to walk inside and outside the house was targeted as well. There was no significant difference in trial results between study and control groups in terms of complications, rehospitalization rates or length of hospitalization.

Soukkio *et al.* (2022) in their study focused on the effect of a 12-month supervised home-based training program on the post-hip fracture patients' performance. The exercise program introduced in the study group was based on OTAGO training. The control group consisted of patients receiving standard rehabilitation. The intervention group showed improvements in IADL score, SPPB and grip strength compared to standard rehabilitation.

Howell *et al.*'s (2023) study tested the effectiveness of HIFE. Patients were divided into 3 groups. Of these, one was the control group, and the other two included patients qualified for the HIFE program. In addition to HIFE training, one of the study groups was controlled with an inertial measurement unit (IMU) which measures movement and body position. All three groups also were assisted by a physiotherapist who modified and tailored exercises to the patient's needs during home visits. Improvements were obtained in FBG, BI and EQ5D parameters in all groups, but without significant differences between them. Also, no group showed significant improvement in balance.

Karlsson *et al.* (2020b) studied the impact of interdisciplinary home-based rehabilitation in patients with dementia after hip fracture. The control group patients received interdisciplinary in-hospital rehabilitation. Participants of the intervention group after interdisciplinary rehabilitation at hospital when no medical contraindications were present have been discharged home. After discharge, they underwent home-based personalized rehabilitation which includes elements such as ADL training, walking exercises and functional

strength and balance compliant with HIFE program. No differences in patients with dementia in study and control groups in terms of falls, postoperative hospitalization length, readmissions, ADL, mortality 1 year after hospital discharge, and the ability to walk after 3 months and after a year were found.

Crotty *et al.* (2019) aimed to study the effectiveness of 4-week post-operative rehabilitation provided at Nursing Care Facilities. Physiotherapy program followed by the intervention group's patients included mobility and muscle strength training. After 4 weeks, increased mobility was achieved in the study group compared to the control group, but no change in quality of life was observed. After 12 months of the study, patients' quality of life measured by the DEMQOL scale was higher in the study group.

Sherrington *et al.* (2020) studied the effect of exercise on improving mobility impairment and reducing the risk of falls. Training was supervised by physiotherapists, who monitored and adjusted the exercise program over a 12-month period. The training plan consisted of lower limb balance and strengthening exercises. Participants were asked to exercise three times a week for 20–30 minutes. There were no significant differences between the groups in terms of mobility improvement and fall risk.

In Schemitsch *et al.* (2020) study the effect of Romosozumab subcutaneous injections at different doses was tested. The results of the treatment used were verified by the TUG score and the RUSH score. These two parameters increased in the drug-receiving group as well as in the placebo group. However, the differences between the groups were not significant. The time to radiological evidence of bone regeneration was similar in both groups.

Hulsbæk *et al.* (2021) tested the effect of anabolic steroid use combined with training and nutritional supplement in hip-fracture patients' rehabilitation. Both, the control and research groups, received identical physiotherapy and nutritional supplementation. In the research group, Nandrolone Decanoate was additionally used. The efficacy of the method in terms of change in maximal isometric knee-extension strength was measured in Nm/Kg using a belt-fixed handheld dynamometer. Non-significant differences between both groups in knee extension strength after the inclusion of anabolic steroid have been found.

Elboim-Gabyzon *et al.* (2019) studied the effectiveness of TENS on mobility and postoperative pain in patients after hip fracture. Both the control and study groups received standard postoperative treatment including the 30 minute physiotherapy. The exercise program consisted of balance, transfer, lower limb and ambulance training. Additionally, the active TENS and sham TENS were provided in study and control groups, respectively. The ambulation distance and mobility increased in the study group. The pain while walking was reduced as well, in comparison to the control group. No effect of active TENS on pain alleviation at rest and night was proven.

Jinli-Guo *et al.* (2019) in their study aimed to test the effectiveness of "upper-body yoga" in elderly patients after hip fracture. The therapy included elements of breath training and slow stretching movements. In short-term results, after 1 week, values of PCF and BI were higher in the study group. After 4 weeks of training the FVC%, PCF, BI increased in the intervention group. The authors noted that upper body yoga may provide a specific method for improving the function of immobilized patients after femoral neck or trochanteric fracture.

In Ortiz-Piña *et al.* (2021) trial the effectiveness of telerehabilitation and rehabilitation at home on the patients' functioning after hip fracture was compared. Both the control and research groups received usual hospital care. Tele-rehabilitation group consisted of patients' receiving three exercise sessions and two occupational therapy sessions. The online program was based on tutorial videos and written instructions. The training plan included balance, strengthening and cardiovascular exercises. The occupational

component included videos presenting advice on how to carry out everyday activities and avoid falls. The control group after discharge received usual in-person rehabilitation at home. Patients using the tele-rehabilitation program had better performance on the TUG and a higher FIM score. The SPPB score was not significantly different in the two groups.

Kim *et al.* (2020) studied the impact of 4-week training on an anti-gravity treadmill on isokinetic muscle activity and strength in post-hip fracture surgery patients. An anti-gravity treadmill by using an air pressure control system eases the impact on lower limbs during training. The control group received the conservative rehabilitation. Both groups showed significant improvement in isokinetic muscle strength and endurance of the hip extensors and flexors. However, there were no between-group differences except in hip extensor muscle strength. The activity of the tested lower limb muscles increased after the intervention. In contrast, significant differences between the groups were observed only in the activity of the gluteus maximus and gluteus medius muscles.

Conclusions

Most studies have concentrated on the comparison of interdisciplinary home rehabilitation with standard rehabilitation. Analyzing the above studies, physiotherapy has a significant role in the recovery of patients after hip fracture. However, not much difference is observed between multidisciplinary therapy and standard physiotherapy and geriatric care provided in the hospital and after discharge. Long-term physical rehabilitation seems to be more effective compared to short-term exercises. It is worth noting that the effectiveness of exercises performed by the patient at home may be improved by instructional videos.

Romosozumab and steroid therapy have not proven effective. Functioning of patients after hip fracture may be improved by alternative methods such as TENS and "upper body yoga". The latter is particularly useful in chronically bed-ridden patients who are unable to perform the conventionally recommended exercises. Home rehabilitation may also be complemented by an antigravity treadmill, which in Kim *et al.* (2020) research has been shown to be effective in improving hip extensor and gluteal muscle strength.

Due to ambiguous study results and insufficient number of studies, it is not possible to determine the effectiveness of the analyzed methods. There is a need for further clinical studies to find suitable rehabilitation methods to improve the condition of post-fracture patients.

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Skróty powinny być zdefiniowane przy pierwszej wzmiance, umieszczając skrót w nawiasie po pełnym tekście. Należy utrzymywać spójności skrótów w całym artykule. Należy unikać stosowania skrótów w tytule i streszczeniu. Skróty mogą być stosowane w tabelach i figurach, jeśli są one wyjaśnione w przypisach tabeli i rycinach.

Nazwy handlowe

W przypadku produktów stosowanych w eksperymentach lub metod (szczególnie te określone przez nazwę handlową), należy podać pełną nazwę producenta oraz lokalizację (w nawiasach). Jeśli to możliwe, używać nazw rodzajowych leków.

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Pierwszej strona maszynopisu powinna zawierać tytuł artykułu, pełne imiona i nazwiska autorów bez stopni i tytułów, afiliacje autorów z miastem i krajem oraz tytuł skrócony nieprzekraczający 40 liter wraz ze spacjami. Pierwsza strona powinna również zawierać dane autora do korespondencji: pełny adres pocztowy, adres e-mail oraz numery telefonu i faksu.

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Streszczenie nie powinno przekraczać 250 słów i powinno być podzielone na oddzielne sekcje: Wprowadzenie, Cel, Materiał i metody, Wyniki i Wnioski. Powinno być zwięzłe oraz wskazywać znaczące wyniki. Streszczenie powinno zawierać od 3 do 6 słów kluczowych. Powinny one odzwierciedlać główny temat artykułu (unikać słów wykorzystanych już w tytule).

The following categories of articles can be proposed to Issue of Rehabilitation, Orthopaedics, Neurophysiology and Sport Promotion – IRONS:

Original papers

Manuscripts in this category describe the original results from the field of rehabilitation, physiotherapy, orthopaedics, and neurophysiology as well as topics dealing with diagnostic and treatment of sport-related traumas. The manuscript should be presented in the format of Summary (250-word limit) and Main text (Title page, Summary, Introduction, Aim, Material and Methods, Results, Discussion, Conclusions, Acknowledgments, Conflict of Interest, References, and Figure Legends). In the Discussion section, statements regarding the importance and novelty of the study should be presented. In addition, the limitations of the study should be articulated. The abstract must be structured and include Introduction, Aim, Material and Methods, Results, and Conclusions. Manuscripts cannot exceed 2700–3000 words in length (excluding title page, abstract, and references) and contain no more than a combination of 8 tables and/or figures. The number of references should not exceed 45. This type of article should include statistical procedures.

Research reports

Manuscripts in this category may present results of studies involving small sample sizes, introduce new methodologies, describe preliminary findings or replication studies. The manuscript must follow the same format requirements as full-length manuscripts. Brief reports should be not less than 2000 words (excluding title page, abstract, and references) and can include up to 3 tables and/or figures. The number of references should not exceed 25. This type of article should include statistical procedures.

Następujące kategorie artykułów mogą zostać zaproponowane do wydawania w Zeszytach Promocji Rehabilitacji, Ortopedii, Neurofizjologii i Sportu – IRONS

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Manuskrypt w tej kategorii opisuje wyniki badań przeprowadzonych w oryginalnym, szerokim obszarze powiązanym z rehabilitacją, fizjoterapią, ortopedią i neurofizjologią jak i dotyczące zagadnień związanych z diagnostyką i leczeniem urazów sportowych. Manuskrypt powinien być przedstawiony w formie streszczenia (limit 250 słów) i tekstu głównego (Strona tytułowa, Streszczenie, Wprowadzenie, Cel, Materiał i metody, Wyniki, Dyskusja, Wnioski, Podziękowania, Konflikt interesów, Piśmiennictwo oraz Objaśnienia rycin). W sekcji Dyskusja należy zaprezentować stwierdzenia dotyczące znaczenia i nowości tych badań. Ponadto w pracy należy zawrzeć ograniczenia przeprowadzonych badań. Streszczenie musi być zrestrukturyzowane i zawierać: Wstęp, Cel, materiał i metody, wyniki i wnioski. Rękopis nie może przekroczyć długości 2700–3000 słów (bez strony tytułowej, streszczenia i piśmiennictwa) i zawierać nie więcej niż 8 tabel i / lub rycin. Ilość przypisów nie powinna przekraczać 45. Ten rodzaj artykułu powinien zawierać procedury statystyczne.

Raporty z badań

Manuskrypt w tej kategorii może przedstawiać wyniki badań z udziałem małej próby, przedstawienie nowych metod, należy opisać wstępne ustalenia lub badania replikacji. Manuskrypt musi mieć tą samą formę co pełnej długości manuskrypt. Raport z badań nie powinien zaigrać mniej niż 2000 słów (z wyłączeniem strony tytułowej, streszczenia oraz piśmiennictwa) i może zawierać do 3 tabel i / lub rycin. Ilość przypisów nie powinna przekraczać 25. Ten rodzaj artykułu powinien zawierać procedury statystyczne.

Case studies

This guide examines case studies, a form of qualitative descriptive research that is used to look at individuals, a small group of participants, or a group as a whole. Researchers collect data about participants using participant and direct observations, interviews, protocols, tests, examinations of records, and collections of writing samples. Starting with a definition of the case study, the guide moves to a brief history of this research method. Using several well-documented case studies, the guide then looks at applications and methods, including data collection and analysis. A discussion of ways to handle validity, reliability, and generalizability follows, with special attention to case studies as they are applied to composition studies. Finally, this guide examines the strengths and weaknesses of case studies. The manuscript must follow the same format requirements as full-length manuscripts. Case Studies should be up to 2700 words (excluding title page, abstract, and references) and can include up to 3 tables and/or figures. The number of references should not exceed 25.

Studium przypadku

Artykuł ten analizuje studium przypadku, forma jakościowych badań opisowych, który jest używany, aby przeanalizować pojedyncze przypadki, małe grupy uczestników, lub grupy, jako całości. Naukowcy zbierają dane dotyczące uczestników badania i bezpośrednich obserwacji, wywiadów, protokołów testów oraz egzaminów. Manuskrypt musi spełniać te same wymogi formatu jak pełnej długości rękopis. Studium przypadku powinno zawierać do 2700 słów (z wyłączeniem strony tytułowej, streszczenia oraz piśmiennictwa) i może zawierać do 3 tabel i / lub rycin. Liczba piśmiennictwa nie powinna przekraczać 25.

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Artykuł ten powinien opisywać najnowsze postępy w dziedzinach należących do zakresu czasopisma. Artykuł przeglądowy nie może przekraczać 2700–3000 słów (z wyłączeniem strony tytułowej, streszczenia i piśmiennictwa) i zawierać nie więcej niż 10 tabel i / lub rycin. Autorzy są zachęcani do ograniczenia ilości tabel i rycin do podstawowych danych, które nie mogą być opisane w tekście. Liczba piśmiennictwa nie powinna przekraczać 60.

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Guidelines should be up to 2000 words (excluding title page, abstract, and references) and can include up to 3 tables and/or figures. The number of references should not exceed 25.

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Wytyczne powinny być do 2000 słów (z wyłączeniem strona tytułowa, streszczenie oraz referencje) i może zawierać do 3 stoły i / lub cyfr. Liczba odniesień nie powinna przekraczać 25.

Acknowledgments

Under acknowledgments please specify contributors to the article other than the authors accredited. List here those individuals who provided help during the research (e.g., providing language help, writing assistance or proofreading the article, etc.). Also, acknowledge all sources of support (grants from government agencies, private foundations, etc.). The names of funding organizations should be written in full.

References

All manuscripts should use the 'Harvard' style for References.

The order of authors in References list is alphabetical, all authors of a single paper are mentioned, Authors should be cited in the text as they appear according to the year of presented papers as follows (example) (Boileau *et al.* 2009; Boileau *et al* 2010; Butt and Charalambous 2012) in (round) brackets. Please check in your list the proper fashion of citation, including year (in a proper place), pages from-to.

Example:

Elhassan, B., Bishop, A., Shin, A., Spinner, R. (2010), *'Shoulder tendon transfer options for adult patients with brachial plexus injury.'* J Hand Surg Am., 35 (7), s. 1211–1219.

Books:

Rang, H. P., Dale, M. M., Ritter, J. M., Moore, P. K. Pharmacology. 5th Ed. Edinburgh: **Churchill Livingstone**; 2003, Phillips, S. J., Whisnant, J. P. *Hypertension and stroke. In: Laragh JH, Brenner BM, Editors. Hypertension: pathophysiology, diagnosis, and management.* 2nd Ed. New York: Raven Press; 1995. pp. 465–478.

Tables

Tables should be typed on sheets separate from the text (each table on a separate sheet). They should be numbered consecutively with Arabic numerals. Tables should always be

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Przykład:

Elhassan, B., Bishop, A., Shin, A., Spinner, R. (2010), *'Shoulder tendon transfer options for adult patients with brachial plexus injury.'* J Hand Surg Am., 35 (7), s. 1211–1219.

Książki:

Rang, H. P., Dale, M. M., Ritter, J. M., Moore, P. K. Pharmacology. 5th Ed. Edinburgh: **Churchill Livingstone**; 2003, Phillips, S. J., Whisnant, J. P. *Hypertension and stroke. In: Laragh JH, Brenner BM, Editors. Hypertension: pathophysiology, diagnosis, and management.* 2nd Ed. New York: Raven Press; 1995. s. 465–478.

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