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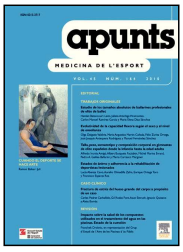

REVIEW

Haemophilia: exercise and sport

Felipe Querol [a,b,*], Sofía Pérez-Alenda [a,b], José Enrique Gallach [c], José Devís-Devís [c], Alejandra Valencia-Peris [c], Luis Millán González Moreno [c]

[a] *Department de Fisioteràpia, Universitat de València, València, Spain*
[b] *Unitat d'Hemostàsia i Trombosis, Hospital Universitari La Fe, Valencia, Spain*
[c] *Department d'Educació Física, Universitat de València, València, Spain*

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Abstract
Physical exercise and sports is one of the basic foundations in the treatment of haemophilia. This article gives a brief description of the characteristics of haemophilia, and through an exhaustive literature review, the importance of the physical condition, as regards prevention and treatment of musculoskeletal lesions in the haemophilic patient, is also analysed.

Haemophilia is a hereditary haematological disease, characteristic orthopaedic lesions. It affects males and has a deficiency of clotting factors which causes haemorrhages, including spontaneous (in severe patients without treatment). The most common lesions are: Haemarthrosis, synovitis, muscle haematomas and haemophilic arthritis. The physical condition of the haemophilic patient, controlled by clotting factor replacement therapy, fundamental and requires physiotherapy, physical exercise and sport.

Based on the recommendations by expert committees of the World Haemophilia Foundation (WFH) and using major data bases and search strategies with key words, 756 references were obtained, of which on 74 passed the inclusion criteria.

The publications were grouped by subject area, differentiating review articles, observational studies and clinical experiences, experimental studies and interventionist actions on specific parameters of physical condition.

It concludes with important evidence on the recommendation of physical exercise and sport in haemophilia, the consensus on its suitability for the physical and social wellbeing of the patients and the need to increase scientific works in this respect.

*Corresponding author:
E-mail: querol@uv.es (F. Querol).

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PALABRAS CLAVE
Hemofilia;
Actividad física;
Ejercicio;
Forma física;
Deporte

Hemofilia: ejercicio y deporte

Resumen
El ejercicio físico y el deporte constituyen uno de los pilares básicos en el tratamiento de la hemofilia. Este trabajo describe un resumen de las características de la hemofilia y, a través de una exhaustiva revisión bibliográfica, se analiza la importancia de la condición física, en relación con la prevención y el tratamiento de las lesiones musculoesqueléticas en el paciente hemofílico.

La hemofilia es una enfermedad hematológica hereditaria, con lesiones ortopédicas características. Afecta a individuos varones y presenta un déficit de factores de la coagulación que provoca hemorragias incluso espontáneas (en pacientes graves sin tratamiento). Las lesiones más frecuentes son: hemartrosis, sinovitis, hematomas musculares y artropatía hemofílica. La condición física del paciente hemofílico, instrumentada mediante terapia sustitutiva de factores de la coagulación, es fundamental y requiere fisioterapia, ejercicio físico y deporte.

Basándonos en las recomendaciones de los comités de expertos de la Federación Mundial de Hemofilia (WFH) y utilizando las principales bases de datos, mediante estrategias de búsqueda con palabras clave, se obtuvieron 756 referencias, de las que tan sólo 74 superaron los criterios de inclusión.

Las publicaciones se agruparon por áreas temáticas, diferenciando artículos de revisión, trabajos observacionales y experiencias clínicas, estudios experimentales y actuaciones intervencionistas sobre parámetros concretos de la condición física.

Se concluye con la evidencia de la importancia de la recomendación del ejercicio físico y deporte en la hemofilia, el consenso en su idoneidad para el bienestar físico, psíquico y social de los pacientes, y la necesidad de incrementar los trabajos científicos al respecto.

Introduction

Exercise and sports was not recommended for hemophilic patients until the last decades of the 20th century. It was not up to the introduction of new clotting factor replacement therapies, which allowed the previously potentially fatal haemorrhaging to be controlled and the level of haemostatic protection to be increased, that the risk of physical activity provoking musculoskeletal bleeding decreased notably. Indeed, the life expectancy of such patients was no longer than 20 years of age.

As well as in general population, a haemophilic patient would benefit from exercise and sport, both because such patients require a good muscle tone to protect their joints from the haemophilic-induced injuries, and those activities contribute to improve their quality of life.

Therefore, in this paper we will discuss the general concepts of haemophilia as regards the most common injuries (primarily musculoskeletal). Later the importance of sport and physical exercise is highlighted and subsequently reviewed, the literature concerning this aspect.

General concepts of haemophilia

Haemophilia is a congenital, recessive clotting disease featured by cerebral (the most dangerous) and musculoskeletal (the most common and disabling) haemorrhages. It is a gender-specific coagulopathy resulting from a factor VIII (FVIII) deficiency in haemophilia A and a factor IX (FIX) deficiency in haemophilia B.[1]

The incidence of haemophilia varies by country although, in general terms, haemophilia A is found in 1 out of every 5,000 males and haemophilia B in 1 out of every 30,000.[2] The life expectancy of a haemophilic patient is currently similar to that of the general population and a large number of patients with severe haemophilia suffers from musculoskeletal injuries. Specifically, in Spain 12.4% of patients younger than 14 years of age suffer from arthropathy[3] (fig. 1).

Clinical classification of haemophilia

The clotting factor levels in plasma, expressed as a percentage (one international unit corresponds to 1%), can be used to classify the severity of haemophilia into three classes: severe (<1%), moderate (1–5%) and mild (>5%-<40%).[4] Bleeding depends on these levels and there are no major differences between haemophilia A and B. Patients with severe haemophilia who are not receiving a specific treatment often suffer spontaneous haemorrhages with no apparent trauma, whereas the bleedings for those with the moderate form are normally related to trauma or excessive effort during physical activity. In contrast, patients with mild haemophilia only tend to bleed after surgery or severe trauma. Patients with levels higher than 40–50% (and female carriers) rarely bleed and do not usually require treatment, although they should be monitored during surgery.[5]

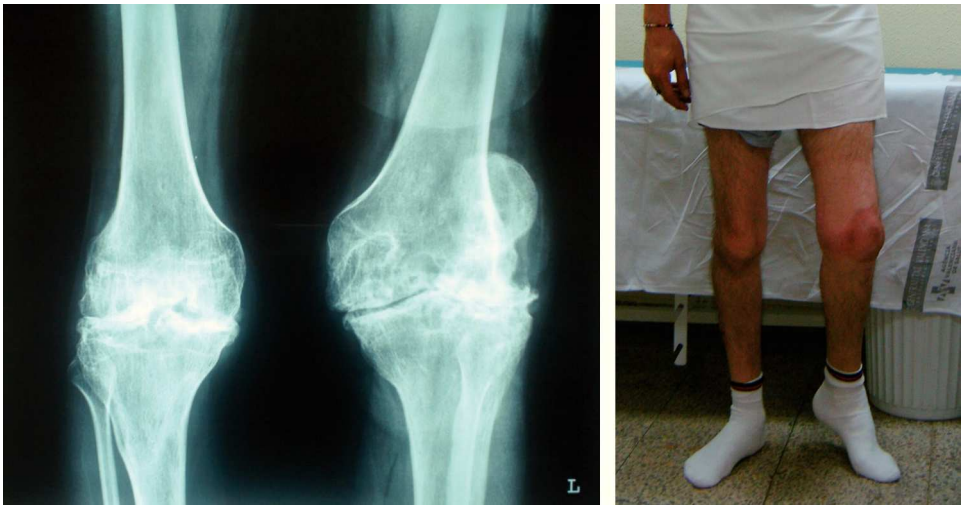

Figure 1 Clinical and radiological images of haemophilic arthropathy in a young adult.

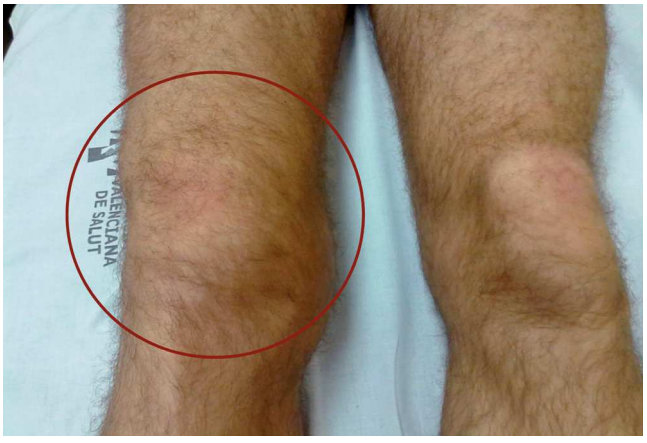

Figure 2 Image showing knee haemarthrosis in a haemophilic patient.

Common injuries

Untreated patients with severe haemophilia can be at high risk from even apparently trivial haemorrhagic processes.[6,7] Musculoskeletal bleeds are by far the most common in haemophilic patients, with haemarthrosis (fig. 2), haematomas and synovitis being the most frequent musculoskeletal injuries.[8] Intra-articular bleeding or haemarthrosis is the most common and best known clinical manifestation of both severe and moderate haemophilia, representing 65–80% of all haemorrhages,[9,10] with the knees, elbows and ankles accounting for the majority (60–80%) of all cases.[3,11] If these bleedings are not treated, or treated incorrectly, in the long term they can lead to irreversible joint damage and haemophilic arthropathy in the second decade of life.[12,13]

Basic treatment

The basic treatment for haemophilic patients involves intravenous administration of concentrates of the deficient clotting factor (fig. 3) in one of two standard modalities: on-demand or prophylaxis. On-demand treatment is the infusion of clotting factor after bleeding with the aim of resolving it,[14] whereas prophylaxis is the routine infusion of FVIII or FIX following a pre-determined routine to prevent bleeding and its complications, mainly haemophilic arthropathy, intracranial bleeding and other forms, which could pose a major risk to the patient's life.[15,16] The introduction of prophylaxis has led to a dramatic reduction in the number of bleeds in children with haemophilia A or B, thereby minimising the impact of the arthropathy.[17,18]

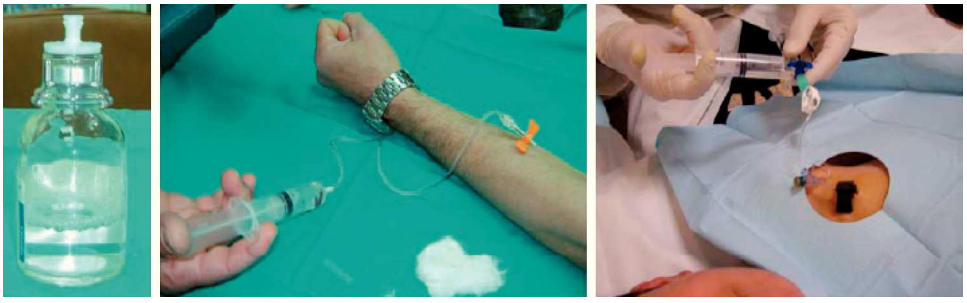

Figure 3 Clotting factor replacement therapy required for any action (injury prevention or treatment) in haemophilic patients.

A physical therapy approach

Haematological treatment alone is not sufficient to prevent and treat musculoskeletal bleeding. Indeed, the combination of this treatment and a sedentary lifestyle in such patients often leads to problems associated with inactivity, such as decreased strength, worse balance and coordination, as well as an increased risk of overweight. These problems promote instability and changes to the joint loads, thus leading to the appearance of new bleeds and increased joint damage. Likewise, in acute cases, if the rest period required after haemarthrosis is not accompanied by the correct physiotherapeutic treatment, a vicious circle of inactivity, which leads to new bleedings and finally haemophilic arthropathy and loss of function, rapidly sets in.[19] Furthermore, it has been shown that this permanent joint damage is associated with a reduction in bone density,[20] even in children with incipient arthropathy.[21]

Haemophilic patients therefore require complementary rehabilitation- and physiotherapy-based treatments, along with physical exercise and sports programs, to improve their musculoskeletal health. This may help to prevent bleeds and speed up the recovery process,[19,22-30] even in those countries where replacement therapy is limited[31,32] or in patients with inhibitors.[33]

Purposes

The purpose of this paper was, firstly, to analyse the existing literature regarding physical activity, exercise and sport in haemophilic patients in order to determine their possible benefits, recommendations, level of physical fitness and most often engaged sports. Secondly, it pretends to identify the most important studies in this area.

Materials and methods

Inclusion and exclusion criteria

Those articles which fulfilled the following criteria were included in this review:

- Studies published as scientific papers whose title or abstract mention a purpose of improving physical fitness in order to rehabilitate musculoskeletal pathologies or simply promote the capacity of haemophilic patients. Those articles in which physical fitness-related descriptive data were presented were also included;
- Studies with an experimental or observational methodological design and/or clinical experiences. Those review articles containing a section related to exercise, sport or improvement in physical fitness were also included;
- Studies published in English.

Studies involving only rehabilitation treatments which were not used as a means of improving physical fitness, physical activity, exercise and/or sport (e.g. surgical treatments) were excluded, as were those articles in which the patients presented coagulopathies other than haemophilia. Finally, books or book chapters concerning one or more of the topics that form the basis of this study, irrespective of whether they appeared in a review article, were also excluded.

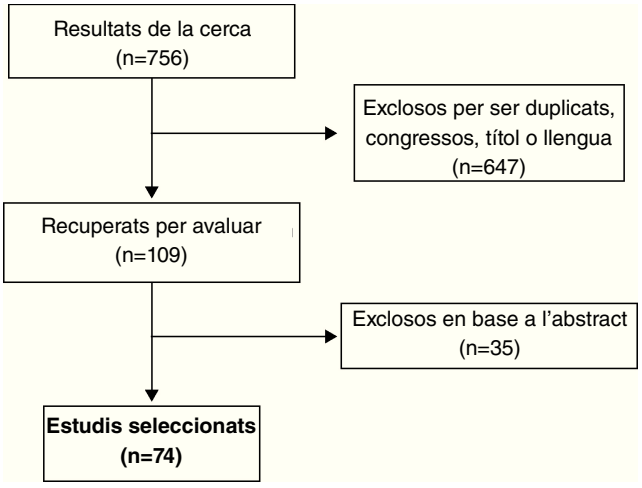

Figure 4 Flow diagram of search process.

Search strategy

The scientific literature from the first date available up to July 2010 was reviewed. Searches were performed in the WOS (Web of Science®), Pubmed, Sportdiscus and Scopus databases using the following keywords and strategy: (physical_activity OR exercise OR physical_fitness OR sport) AND (haemophilia OR hemophilia).

Results and discussion

The initial total of 756 references was reduced to 109 after elimination of duplicate references (the same study in different databases), those belonging to books of abstracts for scientific conferences or meetings, studies whose title was unrelated with the topic in question and those published in a language other than English. The total number was finally reduced to 74 after revision of the abstracts (fig. 4).

The review articles, clinical experiences and observational studies included in this review are listed in table 1 by topics related to physical fitness, physical activity, exercise and sport in haemophilic patients.

The experimental studies focused on physical fitness and published between 1982 and 1999 are shown in table 2. Finally, the experimental studies published in the last decade, when the importance of physical exercise and sport has been recognized more in hemophilia, are shown in table 3.

The benefits of regular physical exercise and sport for the haemophilic patient. Recommendations

According to the literature, the benefits of regular physical exercise and sport for haemophilic patients are numerous and cover various physical and psychosocial aspects as well as others more directly related to the musculoskeletal

Table 1 Studies included in this review by topics related to physical fitness, physical activity and exercise and sport in haemophilic patients

Related topics	References
Review articles	Mulder *et al.* (2004); Wind *et al.* (2004); von Mackensen (2007); Morris *et al.* (2008); Petrini y Seuser (2009); Gomis *et al.* (2009); Philpott *et al.* (2010)
Observational and retrospective studies, and clinical experiences, which study specific aspects of PF	Greenan-Fowler *et al.* (1987); Buzzard (1996); Falk *et al.* (2000); Heijnen *et al.* (2000); Schoenmakers *et al.* (2001); Hilberg *et al.* (2001); Falk *et al.* (2005); van der Net *et al.* (2006); Mihalova (2007); González *et al.* (2007); Fromme *et al.* (2007); Engelbert *et al.* (2008); Tlacuilo-Parra *et al.* (2008); Gallach *et al.* (2008); Tiktinsky *et al.* (2009); Koiter *et al.* (2009); Douma-Van Riet *et al.* (2009); Herbsleb y Hilberg (2009); Ross *et al.* (2009); Hassan *et al.* (2010); Broderick *et al.* (2010); Buxbaum *et al.* (2010); Fearn *et al.* (2010); Sherlock *et al.* (2010); Hill *et al.* (2010)
Observational studies and clinical experiences related to PF	Toy *et al.* (2001); Barnes (2004); Nazzaro *et al.* (2006); Wallny *et al.* (2007); Seuser *et al.* (2007); Hofstede *et al.* (2008); Lobet *et al.* (2008); Khawaji *et al.* (2010)
General recommendations concerning the practice of PA, E and sport	McLain y Heldrich (1990); Jones *et al.* (1998); Buzzard (1998); Beeton *et al.* (1998); Coelho y Cameron (1999); Santavirta *et al.* (2001); Wittmeier y Mulder (2007); Riske (2007); Buzzard (2007); Mahlangu *et al.* (2008); Heijnen (2008); Pediatrics Committee on Sports and Fitness (2001); Heijnen (2008)
Studies described only in abstracts from WFH world conferences	WFH Abstract (2000); WFH Abstract (2002); WFH Abstract (2004); WFH Abstract (2006); WFH Abstract (2008)

PA: Physical Activity; E: Exercise; PF: Physical Fitness; WFH: World Federation of Haemophilia.

symptoms exhibited by these patients.[34] The physical benefits include improved physical characteristics such as strength[35-39] and cardiorespiratory capacity as well as a decreased risk of cardiovascular morbidity and mortality.[40] This is important considering the high incidence of this this type of disease in the elderly and increased life expectancy of haemophilic patients, which in the developed world is similar to that for the general population.[41-43] The psychosocial benefits include higher self-esteem and socialisation, which lead to a better quality of life.[44] Finally, as far as the haemorrhagic symptoms and their after-effects are concerned, exercise can decrease the frequency of bleeds, joint problems and loss of bone mineral density.[45-47]

Despite these benefits, the recommendation that haemophilic patients should undertake physical activity, physical exercise and/or sport is relatively recent.[28,29] Up to 40 years ago, there was no scientific literature to support physical activity, exercise or sport in these population. Indeed, they were more commonly considered to be a cause of injuries.[48]

This new approach to the treatment, care and physical activity constraints for haemophilic patients has been possible, to a large extent, to the availability and safety of the clotting factor concentrates used to treat haemorrhagic problems in the last few years.[48] Research in this area has increased steadily and has provided scientific evidence to

Table 2 Characteristics of the experimental studies performed in the period 1982–1999 included in this review

Authors	Participants	Intervention	Results
Heijnen *et al.* (1999)	20 severe HP	Strength of knee flexors and extensors, and hip abductors and extensors. Walking and postural training. 4 weeks	Improvement in joint contractions
Greenan-Fowler (1987)	10 severe HP	Strength of elbow, knee and ankle flexors and extensors, and cycling, swimming and running. 1 year min. 3 times/week	Adherence to program during the 12 months was 94% in the first three months and 60–84% in the remainder
Pelletier *et al.* (1987)	1 severe HP	Isometric strength at 60% of the maximum voluntary contraction of the quadriceps femoris 3 weeks	Improvement in isometric strength: 40–70%
Green and Strickler (1983)	32 severe HP	Isokinetic strength of knee flexors and extensors	Improvement in isokinetic strength
Koch *et al.* (1982)	HP	Strength with dynamic loads	

HP: Haemophilic patients.

Table 3 Characteristics of the experimental studies performed in the period 2000-2010 included in this review

Authors	Participants	Intervention	Results
Mulvany *et al.* (2010)	33 HP and von Willebrand with arthropathy (7–57 years)	Personalised supervised exercise programs, 6 weeks, 2 sessions/ week; S (40–70%, 10–20 rep, 5–10 s contraction, 1–3 series, concentric exercise) + Flexibility + AR (50–70% HRmax, max. 20 mins)	Significant improvement in ROM, S and AR
Vallejo *et al.* (2010)	13 HPA with arthropathy	Aquatic training program: 9 weeks, 3 times/week, 1 hour/ session 20 mins E exercises and power, + 20 mins AR	Improvement in motor performance and AR: 51.51% VO_2, 37.73% VO_2 rel, 14.68% distance covered (Cooper test with portable gas analyser)
Hill *et al.* (2010)	20 HP and other coagulopoathies (33-45 years)	Individual home-based exercise program S, balance and walking for 4 months (6–8 exercises, 5–7 times/week)	No significant improvements in any parameter, but increases of 5–22% in 10 of the 16 variables studied
Gomis *et al.* (2009)	15 HP (arthropathy) 15 healthy CG	Muscle electrostimulation 8 weeks, brachial biceps (45Hz, 200 μs pulse, 10s on/10s off)	Improvement: 15.8% trophism 4.6% isometric S 37.5% electromyographic activity
García *et al.* (2008)	18 HP (5–13 years): 9 HP with arthropathy and 9 without (CG)	Free active exercise program in warm water 9 sessions; 30 min, twice a week	Improved ROM knees and ankles but not in elbows in HP with arthropathy
Broderick *et al.* (2006)	70 HP (CG and training)	Exercise circuit (twice a week, 1 hour, 12 weeks): E (3 series, 8–12 rep, 20 min) + AR (60–70% HRmax, 30 min max.)	Not available
Harris *et al.* (2006)	13 HP 33 CG	S with weights + swimming, cycling, martial arts, golf, hiking, basketball and/or yoga 3 times/week, minimum 30 mins	Improved ROM in most of the 10 joints studied
Querol *et al.* (2006)	10 severe HPA 10 CG	S with muscle electrostimulation to quadriceps; 6 weeks, 18 sessions, 3 sessions/week of 30 mins each	Improved isometric strength (left leg 13.8%; right leg 17.1%) Improvement in hypertrophy: 24.34%
Stephensen *et al.* (2005)	1 severe HPA before and after knee synovectomy	*Before synovectomy*: S exercises in gym and swimming pool: 2 times/week, 6 months *After synovectomy*: Isometric S exercises quadriceps and walking: 6 months	Improvement in muscle strength Improvement in ROM Rapid recovery of muscle function
Hilberg *et al.* (2003)	9 severe HPA (A) 8 healthy active CG (B) 11 inactive HP CG (C)	(A, B) 6 months, twice a week, 120 mins per session S (low resistances on knee flexors and extensors, 20–25 rep) + proprioception (C) Control situation	Improvement in isometric strength: (A) Extensors 34%; flexors 29% (B) Extensors 20%; flexors 28% (C) No significant changes (A, B) Improved proprioception
Tiktinsky *et al.* (2002)	Patient 1, 2 and 3. Prospective (A) Patient 4, 5 and 6. Retrospective (B)	(A) S with low resistance on wrists and ankles, 1–2 years (B) Same exercise program. 11–21 years (A, B) 3 times a week for 45-60 minutes	(A, B) Increased muscle S (A) Decrease in bleed frequency from 2–3 to 1–2 a week (B) Decrease in bleed frequency to 2–4 a month

HP: Haemophilic patients; CG: Control group; HPA: Patients with haemophilia A; ROM: range of joint movement; rep: repetitions; S: Strength; E: endurance; AR: Aerobic resistance; HRmax: Maximum heart rate.

support exercise for improving physical health problems of haemophilia sufferers. Indeed, physical exercise has become increasingly relevant in the treatment of this congenital coagulopathy, basically to prevent musculoskeletal problems. However, the number of papers published in this field to date remains low.[29]

The physical fitness of haemophilic patients

Several studies have shown that the physical fitness of adult haemophilic patients can currently be considered to be lower than their healthy peers' fitness, especially as regards aerobic resistance,[49] strength[37,50,51] and proprioception and balance.[50,52,53]

The same cannot, however, be said for child and adolescent sufferers, as other studies have shown that haemophilic children have similar levels of functional ability and motor performance to their unaffected counterparts.[54,55] Nevertheless, the existence of differences in terms of the results obtained by different authors for parameters such as aerobic resistance and strength should be noted. Indeed, some recent studies have shown that haemophilic children have a lower aerobic resistance,[55,56] anaerobic resistance and strength[57-59] than their healthy counterparts, whereas others have found similar levels of aerobic resistance,[60,61] strength[55,62] or both.[63,64]

In contrast to adults, those haemophilic children receiving haematological treatment have good balance and proprioception and have much improved joint health.[55,59,61,62] There are very few studies concerning coordination ability, and the only study found suggests a lower coordination respect to their healthy counterparts.[59]

These differences between the physical fitness of adults and the child population may be due to the fact that haemophilic children are more physically active than their adult counterparts.[65] since they are more engaged in sport and physical activity in their leisure time. Sport and exercise play a more important role for haemophilic children and adolescents than for adults.[66,67] Despite haemophilic children and adolescents dedicate the same or more time to sport and physical activity than their healthy counterparts, these studies also note they do not meet the minimum recommended levels for these age groups.[61,62,68] This finding consistent with the increasingly sedentary nature of modern society in both developed and developing countries.[48]

The sedentary lifestyle is reflected in the presence of overweight and obesity in the haemophilic population, especially in children,[55,63,69-71] and the increase in their prevalence in recent years. Although similar to the general population, this increase is worrying as overweight and obesity have a significant influence on morbidity and quality of life, worsening the pre-existing arthropathy and increasing the likelihood of cardiovascular disease.[71]

Haemophilia, exercise and sport

The sports and activities this population most frequently practise differ by region, probably as a result of cultural factors. Thus, for example, German haemophiliacs tend to cycle, swim, run and skate,[66] whereas those in Israel play ball games, walk and run.[72] Football is the most popular sport in Holland, followed by swimming, tennis, gymnastics and cardio-fitness exercises,[62,73] whereas Irish haemophiliacs prefer swimming, golf and football in that order.[65]

Age-related differences as regards the preferred activities have also been reported, with older patients tending to participate in less dangerous activities, possibly due to their increased awareness of the disease and its risks.[72] Furthermore, the predominance of activities, such as swimming or cycling, may be a result of specialists' recommendations for haemophiliac patients.[62]

There are different classifications of recommended and not recommended sports for haemophilic patients. The classification made by the American Pediatric Society, subdivides them into contact, minimal contact and non-contact on the basis of the probability of contact or collision.[74] Examples of the first group include football, basketball and rugby, whereas the second group includes kayaking and various forms of skating, with swimming, tennis and badminton falling into the third category. Other classifications based on the incidence of injuries (high, medium or low risk) are also used. Thus, the recommended sports for haemophiliacs are usually those considered to be no-contact or with a low risk of injury, such as swimming, table tennis, golf and cycling.[75]

Although such classifications can be used as a guide, they are not wholly appropriate or sufficient to definitively suggest which sport a haemophilic patient should practice as contact is not the only cause of injuries in this type of patient. Indeed, sports with a low incidence of injuries can also result in severe or very severe injuries in this population on occasions. In this respect, some researchers have suggested that a biomechanical study of the sport or physical exercise, a physical aptitude test and an orthopaedic analysis of the patient, should be performed in order to help to choose the appropriate preventive physiotherapy and sport.[27,59,67] Thus, preventive physiotherapy could counteract any deficiencies encountered, such as musculotendinous shortening, synovitis or muscular atrophy. This strategy, together with the appropriate orthopaedic modifications,[76] should prepare the patient to practice the sport in question, thereby minimising the risk of injury.[19]

It is important that patients with inhibitors also participate in physical exercise or sports on a regular basis, and the same guidelines and recommendations as for patients with no inhibitors can be applied to determine the suitability of an activity. Swimming is also one of the most widely recommended activities for these patients.[33]

Rehabilitation, physical activity and sport should also be promoted in developing countries, where prophylactic treatment with clotting factor concentrates is not available. In these countries, treatment of bleeds involves physical methods such as rest and ice, and once bleeding has stopped the basic treatment involves a simple exercise program to help to restore joint mobility and strength. Such programs should also include coordination and balance exercises. Sports should also be encouraged, although the choice should be restricted on the basis of minimising the risk of injury and all suitable precautions should be taken in that respect. Furthermore, cultural aspects, ethnicity and the country infrastructure should also be taken into account as

these factors often differ from region to region within the same country.[31]

Sport specialisation is another factor to be considered when haemophilic patients engage in exercise. Thus, muscle imbalances which may arise upon performing repetitive exercises should be avoided in children younger than eight years of age.[67]

As we have seen, although sport is not completely risk-free, the appropriate choice of sport should mean that the benefits, including both emotional and social well-being as well as the obvious physical effects, outweigh the risks for patients with haemophilia.[27] For this reason, the consensus regarding the suitability of including sports in the overall handling of haemophilia is widespread.[44]

However, despite this generalised attitude and the fact that young haemophiliacs, and to a lesser extent adults, view leisure time exercise and sports positively, a large number of patients still thinks that the best treatment for haemophilia involves avoiding physical activity and that joint damage cannot be prevented.[77]

Experimental studies regarding the physical fitness of haemophilic patients

A small number of experimental studies have been performed to investigate the physical fitness of haemophilic patients as a consequence of the dominant scientific knowledge, up to the 1970s, against physical activity and sport for these patients. The low prevalence of this disease and the geographical spread of its sufferers, also contributed to it.

A recent review concerning exercise and sport as part of the treatment regime for haemophilic patients[29] has also highlighted the existence of methodological problems in these studies, such as a lack of clarity regarding the training protocols, which limit the ability to compare the results obtained by different authors.

Gomis et al.[29] have summarised the experimental studies involving haemophilic patients up to 2006. The first studies were published in the 1980s, and only five studies were found until the end of the 1990s. The most important feature is that these studies involved an intervention intended to improve strength[35,78-81] (table 2). One of them also included postural training and another combined both sport (running, cycling and swimming) and strength training. In all cases, the studies produced positive results.

The number of publications has increased only slightly this century, with twentyfour studies considered by Gomis et al. published between 2000 and 2006 (29). These group of studies, except six works,[36,37,45,46,82,83] were presented at the conferences of the Word Federation of Haemophilia, and therefore the information available from them is limited.[84,85] Although a variety of interventions has been developed, the majority still involves muscle strength training in combination with either general training programs or others aimed at improving proprioception and balance, the range of joint movement or the aerobic resistance. The methods used to improve these capacities also varied, ranging from exercises with small loads, muscle electrostimulation and various therapeutic physical exercises (e.g. kinesitherapy and hydrotherapy) to sport activities such as football, swimming, cycling and basketball. The results of these studies were favourable an included improvements in the physical capacity concerned, a reduction of the frequency of haemarthrosis and improvements to synovitis (table 3).

The studies published between 2006 and the present day continue to be dominated by observational rather than experimental studies. Indeed, only five of the latter were recently found for this period[38-40,86,87] (table 3). In three of them, an improvement in strength was one of the key results. Gomis et al.[38] studied the effects of an eight-week electrostimulation protocol on the brachial biceps in severe haemophilic patients with arthropathy and found a 15.8% increase in the cross-section of this muscle, a 37.5% increase in electromyographic activity as well as a 4.6% increase in isometric strength in the 15 patients who underwent training. Likewise, Hill et al.[87] developed a personalised home-based exercise program involving between 6 and 8 strength, balance and walking exercises. This protocol was applied to a group of 20 adults with haemophilia or another type of coagulopathy for between five and seven times a week for a total of four months. In this case, despite the improvement observed in some of the study variables, the results obtained were not statistically significant. Mulvany et al.[39] also developed a personalised, but this time supervised, exercise program, with a shorter duration (6 weeks), involving exercises intended to improve strength, range of joint movement and aerobic resistance. A total of 33 haemophilic and von Willebrand child and adult patients, all with arthropathy, participated in this study. In this case the training program resulted in an improved musculoskeletal status and physical fitness, as evidenced by the significantly increased range of joint mobility, strength and aerobic capacity.

The other two studies published recently involved exercise protocols in an aquatic environment.[40,86] In this respect, it should be noted that swimming and aquatic activities have been, and continue to be, widely recommended in the scientific literature[33,88] and most often practised by haemophilic patients.[62,66,80] This widespread recommendation and patient approval for swimming, hydrotherapy and aquatic activities in general is a result of the advantages arising from the characteristics inherent to the aquatic environment itself,[89] including the sensation of weightlessness, the temperature and the hydrostatic pressure. However, despite the numerous advantages provided by the aquatic environment for the performance of exercises by haemophilic patients, its widespread recommendation has received, surprisingly, little scientific backing. Indeed, the majority of these studies are experiences published at international conferences rather than in peer-reviewed scientific journals.[90-92]

The study reported by García et al. in 2009[86] was the first to describe the treatment protocol followed, which was designed to improve the range of joint mobility in patients with arthropathy, in any detail. This protocol involved free active movements in warm water, including pedalling in deep water with a float under the armpits (10 mins), breathing control exercises (3 mins), rotation control exercises about different axes (10 mins) and flotation and balance tasks (7 mins). A total of 18 haemophilic children, 9 with arthropathy and 9 without, participated in this study

(8 sessions, twice a week, 30 mins/session). This protocol was found to result in an increased range of joint mobility for the knees and ankles of those children with arthropathy.

Likewise, Vallejo et al.[40] designed a training protocol in an aquatic environment intended to improve the aerobic capacity and motor performance of adult haemophilic patients with arthropathy. This program consisted of 27 sessions (3 sessions/week, 1 hour/session) in which the patients worked on their aerobic resistance, strength and power by way of aquatic fitness exercises and other modified exercises based on conventional swimming styles. This protocol was described in full along with details concerning the exercises performed, microcycles, the materials used and the intensity of effort. The 13 participants in this study performed a Cooper test with a portable gas analyser both beforehand and afterwards to determine the effects produced. The significant increases observed in VO_2 (51.51%), relative VO_2 (37.73%) and distance covered during the test (14.68%) clearly show that the protocol designed by this research group improves the aerobic capacity and motor performance in haemophilic patients with arthropathy.

Conclusions

The analysis developed in this paper highlights the changes that have occurred over the past few years as regards the role of exercise and sport in the field of haemophilia. Partly as a result of related pharmacological breakthroughs, these activities have evolved from enemies to allies of these patients.

Indeed, there is nowadays a widespread consensus regarding the suitability and necessity to include physiotherapy, exercise and sports programs when considering haemophilic patients due to the physical, social and emotional benefits for their well-being.

Furthermore, current recommendations regarding physical exercise and sport are not restricted to those patients receiving clotting factor treatment but can be extended to cover those who live in less developed countries where such treatments are limited or non-existent. Physical exercise and sport are also recommended for patients with inhibitors.

It is important to remember, however, that despite these common recommendations for the haemophilic population, it is still necessary to consider musculoskeletal status, type of activity and its biomechanics, before indicating or contraindicating these activities for each patient at any particular time.

Finally, it should be noted that there are still only a limited number of scientific studies to support the efficacy of many of these widely recommended activities, therefore much work remains to be done in this field.

Conflict of interest

The autors hereby declary that they have no conflict of interest.

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