High Prevalence of Self-Reported Symptoms of Digital Ischemia in Elite Male Volleyball Players in the Netherlands : A Cross-Sectional National Survey

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High Prevalence of Self-Reported Symptoms of Digital Ischemia in Elite Male Volleyball Players in the Netherlands

A Cross-Sectional National Survey

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Background: In the past 3 years, 6 volleyball players with ischemic digits and small microemboli in the digital arteries of the dominant hand presented themselves in our hospital. These complaints were caused by an aneurysmatic dilation of the posterior circumflex humeral artery (PCHA) with distal occlusion and digital emboli in the isolateral limb. All were elite male volleyball players active in the national top league. Little is known about the exact symptoms associated with PCHA pathological lesions with digital emboli (PCHAP with DE) and its prevalence in elite volleyball players. If vascular injury can be identified at an early stage, thromboembolic complications and irreversible damage to the digits might be prevented.

Purpose: To assess the prevalence of symptoms that are consistent with digital ischemia and may be caused by PCHAP with DE in elite male volleyball players in the Netherlands.

Study Design: Cross-sectional study; Level of evidence, 3.

Methods: A questionnaire survey was performed among elite volleyball players in the Dutch national top league and the Dutch beach volleyball team. The questionnaire was constructed using literature-based data on symptoms associated with PCHAP with DE, together with data retrieved from medical files.

Results: A total of 99 of the 107 athletes participated, with a response rate of 93%. The most frequently reported symptoms associated with PCHAP with DE were cold, blue, or pale digits in the dominant hand during or immediately after practice or competition. The prevalence of these symptoms ranged from 11% to 27%. The prevalence of cold digits during practice and competition was 27%. The prevalence of cold, blue, and pale digits during or immediately after practice and competition was 12%.

Conclusion: An unexpectedly high percentage of elite volleyball players reported symptoms that are associated with PCHAP with DE in the dominant hand. Because these athletes are considered potentially at risk for developing critical digital ischemia, further analysis of the presence of digital ischemia and PCHA injury is warranted.

Keywords: volleyball; digital ischemia; aneurysm PCHA

In the past 3 years, we have seen increased numbers of volleyball players with ischemic digits of the dominant hand. Following angiography of the hand and forearm, some of these players showed small microemboli in the digital arteries and were given thrombolytic therapy (Figure 1). Within weeks after return to play, these players returned with identical complaints. Further evaluations, including angiography of the shoulder, showed an aneurysmatic dilation of the posterior circumflex humeral artery (PCHA) with thrombus formation and emboli in the digital arteries of the isolateral limb (Figures 1 and 2). These players were treated by ligation of the PCHA to prevent further embolization and after rehabilitation returned to play at the highest level of competition after several weeks. All were elite male volleyball players playing in the national top league and were between 21 and 31 years of age.

In the Netherlands, with a total population of about 17 million, volleyball is 1 of the top 3 team sports and is played by more than 125,000 athletes on different levels.

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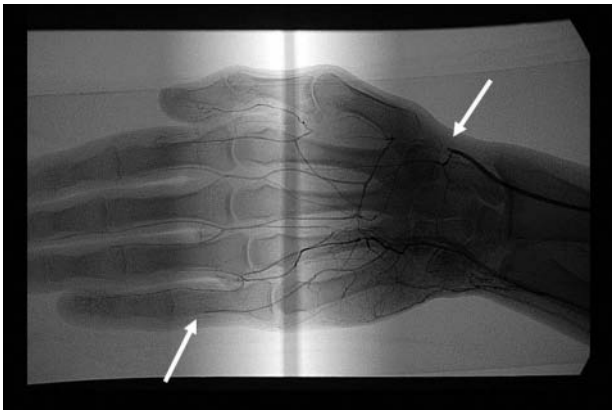

Figure 1. Digital subtraction angiography of the right hand of a 27-year-old volleyball player with ischemic symptoms of multiple digits. The arrows point to multiple abrupt stops in digital arteries, compatible with microemboli.

Of these athletes, some 110 elite volleyball players are active in the Dutch national top league. The presence of an aneurysm of the PCHA is a rare entity found in elite volleyball players[11,15,16,23,26] and often occurs at the origin of the PCHA but can also involve the axillary artery.[8] Besides volleyball players, PCHA pathological lesions with digital emboli (PCHAP with DE) have also been described in the literature in baseball pitchers.[1,6,9,10,14,21,25] During the spiking or serving motion in volleyball, when the humeral head acts to compress the aneurysmal PCHA and the intraluminal thrombus like a tube of toothpaste, thrombi can be extruded from the aneurysmal artery branch into the axillary artery and embolize to the circulation of the forearm, hand, and digits.[6,8,10] The embolic complications of the affected extremity, in combination with pain and ischemia, can lead to the manifestation of this entity.[15,16,26]

The aneurysm is occult as long as the player is free of symptoms,[26] and collateral flow is so abundant that symptoms may not occur except at the highest levels of exercise.[8] It is therefore recommended that these athletes be kept under periodic surveillance to detect an arterial injury or abnormality to prevent irreversible damage.[11,21] However, little is known about the exact symptoms associated with PCHAP with DE in elite volleyball players or the exact prevalence of these symptoms in these players. Many players would presumably have some degree of compression of the PCHA in an abducted and externally rotated position but will never develop any clinical abnormality requiring treatment.[11,21] Therefore, active surveillance of elite volleyball players with these symptoms could clarify the prevalence of these symptoms associated with PCHAP with DE. This type of surveillance has not been performed to date. Also, no screening or surveillance is currently available for this diagnosis. If a vascular injury can be identified at an early stage in these volleyball players who experience apparently innocuous symptoms, thromboembolic complications and irreversible damage to the digits might be prevented.[11,21] The aim of the present study

Figure 2. Digital subtraction angiography of the right arm of a 27-year-old volleyball player with ischemic symptoms of multiple digits (the same player as in Figure 1). The arrow points to the abrupt stop of contrast in the posterior circumflex humeral artery caused by thrombosis.

was (1) to assess which symptoms are most likely associated with PCHAP with DE and (2) to assess the prevalence of these symptoms in the dominant limb among elite male volleyball players in the Dutch national top league and in the Dutch beach volleyball team.

MATERIALS AND METHODS

Study Design

A cross-sectional questionnaire survey was completed among elite volleyball players in the Dutch national top league and the Dutch beach volleyball team.

Participants

In cooperation with the Dutch Volleyball Association (Nevobo), all team managers of the Dutch national top league teams and the Dutch beach volleyball team were contacted and asked to participate in the study. After permission had been granted by the coaches, a researcher (D.v.d.P.) visited the team, explained the aim of the study and the type of injury that they were potentially exposed to, and requested that the questionnaire be filled in right after a practice session during the competitive season. Participation was voluntary and anonymous. Questionnaires and return envelopes were left behind for players absent at the time of the visit. This survey was administered

TABLE 1
Survey Questions Regarding the Individual Player and Specific Symptoms Associated With Digital Ischemia

1. What is your age?
2. What is your body height?
3. What is your body weight?
4. How many years in total have you played volleyball?
5. How many years have you played professional volleyball?
6. How many hours in total do you play volleyball in a week (training and competition)?
7. Does cardiovascular disease occur in your family?
8. Do you smoke or have you smoked in the past?
9. Do you suffer from 1 or more cold fingers in your dominant hand
a. during practice or competition?
b. immediately after practice or competition?
10. Do you suffer from 1 or more blue fingers in your dominant hand
a. during practice or competition?
b. immediately after practice or competition?
11. Do you suffer from 1 or more pale fingers in your dominant hand
a. during practice or competition?
b. immediately after practice or competition?

once during the 2010-2011 season. After 1 and 3 weeks, a polite reminder was sent by e-mail, requesting that the questionnaire be returned within 1 month after the initial group session. No official approval of the Medical Ethics Review Committee at our academic hospital was needed for this questionnaire survey to be conducted.

Questionnaire Content

After a literature review, a questionnaire was developed to detect ischemic symptoms using reports of the same patients with confirmed abnormalities of the PCHA. The focus of the study was to detect ischemic symptoms known to be associated with DE from an abnormal PCHA and to determine the frequency of these symptoms. The symptoms are usually temporary and resolve after volleyball participation. This preliminary survey was evaluated by 4 members of the Dutch beach volleyball team to improve its readability. The questionnaire comprised 2 general domains: those regarding the individual player and those regarding specific symptoms associated with digital ischemia. The questions used in this study are shown in Table 1.

Symptoms From Medical Literature

A search in PubMed and SPORTDiscus was performed to identify studies that reported on cases of PCHAP with DE. The search was carried out from the earliest date possible to July 7, 2011, using a combination of the following keywords (MeSH and/or text words): "aneurysm" AND "posterior circumflex humeral artery" AND "volleyball." This resulted in 4 references in PubMed and 1 reference in SPORTDiscus. Studies were included if they reported on at least 1 case of PCHAP with DE in elite volleyball players and if symptoms of the disease were reported. After checking for duplicates, this resulted in the inclusion of 3 studies. Furthermore, checking the reference list of the included studies resulted in 1 additional study. Finally, an expert at our academic hospital suggested 1 more study, resulting in 5 studies being included: 5 case reports on a total of 9 elite volleyball players with PCHAP with DE.[11,15,16,23,26]

Symptoms From Medical Files

An expert on sports radiology (M.M.) provided a list of elite volleyball players who visited our academic hospital with complaints suspected of being a vascular injury. These medical files were analyzed, and patient reports were included if they involved volleyball players at a national or regional level diagnosed with PCHAP with DE without another comorbidity and if they received treatment at our hospital for the injury. Six patients were included, all between 21 and 31 years of age, who were treated in the period between November 2008 and November 2010.

Table 2 shows that in the medical literature, 89% of the patients reported cold digits in general and that 56% reported this complaint during or immediately after practice or competition. For the sake of clarity, in 44% of the patients, the presence or absence of these complaints was not reported. Furthermore, 89% reported discolored digits (blue or pale), and 67% reported pain in the digits in general (Table 2). In the medical files, 100% of the patients reported cold digits in general as well as 100% during or immediately after practice or competition. Moreover, 50% reported discolored digits, and 50% reported pain in the digits in general (Table 2). All the above-mentioned symptoms were reported in the dominant hand.

Selection of Symptoms Associated With PCHAP With DE

To specify which symptoms are most likely associated with PCHAP with DE, the symptoms mentioned in the medical literature and medical files were reviewed (Table 2). We decided that symptoms suggesting an association should be reported as present in at least 50% of the patients from the medical literature and/or medical files and should not be reported as absent in these patients. As shown in Table 2, only complaints of cold digits in general, cold digits during or immediately after practice or competition, and discolored digits (all in the dominant hand) met this criterion. General pain was excluded because 1 patient reported the absence of this symptom. In addition, it is hard to distinguish ischemic pain from pain resulting from trauma, and as a result, a positive answer on this question could potentially lead to high false-positive rates because of this symptom. Finally, this decision was supported by Jackson,[8] who stated that the signs of ischemia that typically distinguish arterial injuries from musculoskeletal injuries are those of changes in temperature and color.

TABLE 2
Symptoms Associated With Posterior Circumflex Humeral Artery Pathological Lesions With Digital Emboli in the Dominant Arm in Elite Volleyball Players[a]

Symptoms	Medical Literature (5 Studies, 9 Patients): Yes/No/Not Reported	Medical Files (6 Files, 6 Patients): Yes/No/Not Reported
Cold digits		
In general	8/0/1	6/0/0
During or immediately after practice or competition	5/0/4	6/0/0
Provoked by cold circumstances	2/0/7	3/0/3
Discolored/blue/pale digits	8/0/1	3/0/3
Pain in digits		
In general	6/1/2	3/0/3
Provoked by cold circumstances	0/1/8	1/0/5
Pain in forearm	2/0/7	0/0/6
Pain in shoulder	0/1/8	2/0/4
Pressure pain of the palm of the hand	0/0/9	1/0/5
Cramping of the palm of the hand	1/0/8	0/0/6
Sensibility		
Dysesthesia or paresthesia in digits	3/4/2	2/0/4
Decreased sensibility or numbness in digits	1/3/5	1/2/3
Early arm fatigue or less endurance	0/1/8	1/0/5
Decrease in arm strength	0/1/8	1/0/5
Splinter hemorrhages under nails	2/0/7	0/0/6
Swelling of the digits	1/0/8	0/0/6

[a]Values are expressed as number of patients in each category.

Additionally, these symptoms had to occur during or immediately after practice or competition because symptoms are most likely to occur at high levels of exercise,[8] when during the spiking motion in volleyball, thrombi can be extruded from the aneurysmal PCHA into the axillary artery and embolize to the circulation of the forearm, hand, and digits.[6,8,10] This is supported by the high percentage of patients who reported cold digits specifically during or after practice or competition (Table 2). Table 1 shows the formulated questions based on these symptoms labeled as associated with PCHAP with DE, as asked in the questionnaire.

Data Analyses

The data from the returned questionnaires were entered in SPSS (version 16.0, SPSS Inc, Chicago, Illinois). The questionnaires were randomly checked for correct data entry by a second researcher (P.F.M.K.). The mean, standard deviation, minimum, and maximum of age, body height, body weight, total years playing volleyball, years playing professional volleyball, and weekly hours playing volleyball in practice or competition were reported for the group as a whole. Also, the percentages of volleyball players who reported a family history of cardiovascular disease and (had) smoked were reported.

The prevalence of symptoms associated with PCHAP with DE was calculated in the following manner: the percentage of all volleyball players who sometimes or more often reported having cold or blue or pale digits in the dominant hand during or directly after practice or competition. The prevalence of a combination of these symptoms associated with PCHAP with DE was calculated in the following manner: the percentage of all volleyball players who sometimes or more often reported having cold and blue and pale digits in the dominant hand during or directly after practice or competition.

RESULTS

Participants

Ten of the 11 included volleyball teams participated in our study. Ninety-nine of the 107 included volleyball players completed and returned the questionnaire, with a response rate of 93%. On average, participants were 24 years old, had a body height of 196 cm, had been playing professional volleyball for 4 years, and played volleyball 17 hours a week (Table 3). Fifty-one percent of the participants reported that there was no presence of cardiovascular disease in their family, 29% gave an affirmative answer, and 20% reported they did not know (n = 98). Seventy-eight percent of the participants reported that they did not smoke and never had smoked in the past, and 22% smoked or had smoked in the past.

Prevalence of Symptoms Associated With Digital Ischemia in Dominant Hand

The prevalence of complaints of cold digits during practice or competition in the participants was 27% (Table 4). In this group of participants (n = 27), 41% reported that there was no presence of cardiovascular disease in their family (n = 11), 41% gave an affirmative answer (n = 11), and 18% reported they did not know (n = 5). Also, in this group

TABLE 3
Individual Characteristics of the Participants

	n	Mean	Standard Deviation	Minimum	Maximum
Age, y	99	24	5	16	38
Body height, cm	99	196	7	168	211
Body weight, kg	99	87	7	70	110
Years of volleyball	99	14	5	4	30
Years of professional volleyball	97	4	4	1	18
Hours of volleyball per week	99	17	6	5	30

TABLE 4
Prevalence of Symptoms Associated With Digital Ischemia During or Immediately After Practice or Competition in the Dominant Hand in Elite Male Volleyball Players (n = 99)[a]

	During Practice or Competition				Immediately After Practice or Competition			
	Total	Sometimes	Often	Always	Total	Sometimes	Often	Always
Cold digits	27[b]	18[b]	8[b]	1[b]	17	13	4	0
Blue digits	18	13	4	1	11	9	2	0
Pale digits	20	15	4	1	12	11	1	0

[a]Values are expressed in percentages.
[b]n = 98.

of participants, 70% reported that they did not smoke and never had smoked in the past (n = 19), and 30% smoked or had smoked in the past (n = 8). The prevalence of complaints of cold digits immediately after practice or competition in the participants was 17%. The prevalence of complaints of blue digits during and immediately after practice or competition was 18% and 11%, respectively. The prevalence of complaints of pale digits during and immediately after practice or competition was 20% and 12%, respectively (Table 4).

The prevalence of participants who sometimes or more often reported complaints of a combination of cold and pale and blue digits during or immediately after practice or competition was 12%. The reported prevalence of a combination of cold and blue digits was 17%, the reported combination of both cold and pale digits was 19%, and the reported combination of blue and pale digits was 12% (Table 5).

TABLE 5
Prevalence of Symptom Combinations Associated With Digital Ischemia During or Immediately After Practice or Competition in the Dominant Hand in Elite Male Volleyball Players (n = 99)[a]

	During or Immediately After Practice or Competition
Cold AND blue AND pale digits	12
Cold AND blue digits	17
Cold AND pale digits	19
Blue AND pale digits	12

[a]Values are expressed in percentages.

DISCUSSION

The main finding of this questionnaire survey among 99 elite volleyball players is that 27% of respondents reported that they sometimes or more often suffered from cold digits in the dominant hand during practice or competition, with 17% reporting this complaint immediately after practice or competition. Moreover, 12% suffered from a combination of cold and pale and blue digits in the dominant hand during or immediately after practice or competition. One would not expect such high rates of complaints, highly related to digital ischemia and potentially caused by vascular disease, among young, healthy, and fit elite athletes with a mean age of 24 years.

Strengths and Weaknesses of the Study

A total of about 110 elite volleyball players across 10 teams are active in the Dutch national top league. Nine of these teams participated in the study, and 91 of the 99 players from these teams completed the questionnaire as well as 8 of 8 elite volleyball players from the Dutch beach volleyball team. As a result, 99 of 107 players completed the survey, with a response rate of 93%. Because of this high percentage, the obtained results are representative of the actual prevalence of reported complaints associated with digital ischemia and potentially because of PCHAP with DE among male elite volleyball players in the Netherlands in the 2010-2011 season.

Because the surveyed symptoms were derived from data from the medical literature, together with data retrieved from medical files, these symptoms are related to digital ischemia and potentially caused by vascular disease. This contributes to the content validity of our questionnaire.

Moreover, the symptoms were surveyed in a clear and understandable language and are easily recognized by the players, ensuring the reliability of the answers. The sensitivity and specificity of the surveyed symptoms for digital ischemia and PCHAP with DE in our study population have yet to be determined. The presence of these symptoms in elite volleyball players can also be explained by a wide variety of vascular lesions including cardiac embolism, atherosclerosis, vasculitides, arterial thoracic outlet syndrome, hypothenar hammer syndrome, quadrilateral space syndrome, and vasomotor disorders such as Raynaud phenomenon. Given the young age of these athletes, and their high levels of fitness, the presence of cardiac embolism, atherosclerosis, and vasculitides seems unlikely to be the cause of the complaints. Of the other disorders, Raynaud phenomenon is the most common, with a prevalence of 8% in white men in the United States[24] and 1% to 10% in Dutch men depending on the definition used.[2] In contrast, the median age at onset of primary Raynaud phenomenon is 14 years,[27] while secondary Raynaud phenomenon often arises after the age of 40 years with the underlying disease frequently evident at the time of disease onset.[3] Furthermore, Raynaud phenomenon spreads symmetrically to all fingers of both hands.[27] The other disorders are even less common in this demographic. Therefore, other potential causes are considered less likely. Because the symptoms of the abovementioned lesions overlap that of digital ischemia and PCHAP with DE, sports medicine specialists should remain alert to the possibility of vascular injury in elite athletes using repetitive overhead arm motions and complaining of ischemia-related symptoms.[1,8,11,13,21] When an athlete presents with these symptoms, further investigation should demonstrate which exact condition is the cause. It is important to realize that all these diseases should be taken seriously and, if not diagnosed in time, can lead to significant functional impairment and a worsened prognosis.

To verify whether the symptoms described in the study population are actually associated with digital ischemia and PCHAP with DE, additional research is required. Contrast arteriography is the gold standard for visualizing the upper limb arterial system,[7] with computed tomography angiography[7] and magnetic resonance angiography[4] as alternatives. However, these methods are time consuming, expensive, and invasive. An alternative might be noninvasive vascular laboratory testing like the measurement of finger pressures and waveforms. Although these studies can confirm or rule out digital ischemia, they cannot identify the source of injury in the face of an abnormal test result.[8] Additional imaging like ultrasound with Doppler is an easy, quick, and reliable way to assess the axillary artery and its branches, like the PCHA, and thus identify any incipient compression, thrombosis, or aneurysm.[9,18-20] These methods provide a noninvasive and quick way to assess the sensitivity and specificity of our questionnaire regarding the prediction of digital ischemia and PCHAP with DE.

Implications for Practice

The high prevalence of suspicious complaints among healthy volleyball players suggests that the number of volleyball players seen with symptoms of digital ischemia potentially as a result of PCHAP with DE represents only a fraction of the number of volleyball players who suffer from less innocuous symptoms of ischemic digits. This may be the result of an early stage of this disease, stressing the importance of active surveillance and a better insight into modifiable risk factors to achieve effective prevention.

Active surveillance should make it possible to identify a vascular injury at an early stage in those volleyball players who experience apparently innocuous symptoms. In this way, thromboembolic complications and irreversible damage to the digits might be prevented,[11,21] thereby possibly making surgical ligation of the PCHA unnecessary. This type of surveillance among elite volleyball players to identify those with PCHA compression, thrombosis, or aneurysm has not been performed to date because this type of screening could potentially lead to many false-positive results.[11,21] However, the team physician could offer a short screening questionnaire, for example, twice a year, to his or her team to identify those players with inducing or exacerbating complaints of cold or discolored digits. Because symptoms mostly occur during practice or competition, surveillance might be most relevant after periods with increased physical activity, such as a few weeks after the start of the training season and a few weeks after the winter recess. Players might be more vulnerable in these periods. In this way, players with suspicious symptoms can be selected, and after history taking and a physical examination, a referral for the appropriate vascular tests can be made. Moreover, by completing the questionnaire, the volleyball player himself hopefully becomes more aware that the apparently innocuous symptoms can ultimately lead to a serious injury. The characteristics of this condition meet most of the criteria of Wilson and Jungner[28] and would therefore be suitable for surveillance.

Furthermore, given the high prevalence of complaints suspicious to digital ischemia in this young population of healthy athletes, modifiable risk factors should be identified to achieve effective prevention. Potential risk factors include personal, sports-related, and work-related risk factors. An example of a personal risk factor is an anatomic variance of the origin of the arteria circumflexa humeri,[25] possibly resulting in a predisposition for vascular injury.[17] This anatomic variation has not been described in our included medical files and case reports. Examples of sports-related risk factors are the number of hours playing volleyball in a week, the number of spikes in a practice session, position in the field, and number of hours performing strength training above shoulder height. McIntosh et al[11] suggested that guidelines need to be developed for practice time and/or number of hits per day. Finally, the influence of physical strain during daily working activities could be a contributing factor. Examples might be working with vibrating tools and performing repetitive work with the arms above shoulder height.[5,12,22,29]

In conclusion, symptoms of cold, blue, or pale digits in the dominant hand during or immediately after practice or competition are related to digital ischemia and seem to be associated with PCHAP with DE. An unexpectedly high percentage of interviewed elite male volleyball

players in the Netherlands reported these symptoms: depending on these symptoms (or a combination of them), the prevalence varied between 27% and 11%. Because these athletes are considered potentially at risk for developing critical digital ischemia, further analysis of the presence of digital ischemia and lesions of the PCHA is warranted. In addition, more attention should be given to periodic surveillance and prevention.

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