The relationship between sports and polyphenols: a retrospective analysis of PubMed publications over the last 52 years

Relaţia dintre sport şi polifenoli. O analiză retrospectivă a publicaţiilor PubMed din ultimii 52 ani

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Abstract

Background. Sport (S) and polyphenols (P) represent subjects of research interest, but the relationship between them has been seldom investigated.

Aims. The purpose of the present paper is the evaluation of research concerning the S-P relationship, by the retrospective analysis of PubMed publications over the past 52 years.

Methods. The relationship between S and P was evaluated over two segments of time. A) The 1960-2012 period, where the following were considered: a) the key words "S and P"; b) each year of 1960-2012; c) some of the filters for selection of information provided by the PubMed site, B) The recent period, 2010-2012, where the following were considered: a) the key words "S", "P", "S and P"; b) some types of P; c) each type of P analyzed in combination with the key word S. Statistical evaluation was made on the basis of the Student test.

Results. There are significant differences between the means over 52 years: for the total number (T) of publications, abstracts and full text compared each of them to free full text (FFT); between age groups 19-44 and 65-plus, 19-plus and 45-64, and 19-plus and 65-plus; English and other languages; Journal article (JA) - Randomised controlled trial. In the years 2010-2012, the number of publications for "S" and for "P" is significantly increased compared to that for "S" and "P"; the number for each type of P is higher than for S and every type of analyzed P.

Conclusions. 1) The total number of publications over 52 years is low, 35. 2) The number of FFT is reduced compared with T, which could be an impediment to consult the details for those with modest financial possibilities, but the language of publication of the summaries being English, the access to reliable information is greatly facilitated. 3) The studies in human subjects were the favorites, especially men, mostly aged between 19-44 years. 4) The type of publication the most commonly chosen, of the selected item, was JA. 5) Studies on "S AND P" are diversified across several types of P and out of 17 studies for the years 2010-2012, 16 have favorable conclusions for the use of P in S. 6) The relationship between S and P, although summarily represented numerically, is important through the individual value of S and P, as well as the increasing interest by opening up their use in research related to S.

Keywords: sports, polyphenols, types of polyphenols, PubMed filters.

Rezumat

Premize. Sportul (S) şi polifenolii (P) reprezintă subiecte de cercetare de interes, dar relaţia S-P este modest investigată.

Obiective. Scopul lucrării prezente îl constituie evaluarea preocupărilor de cercetare pentru relaţia S-P, prin analiza retrospectivă a publicaţiilor PubMed din ultimii 52 de ani.

Metode. Relaţia S-P a fost analizată pe două segmente de timp. A) Perioada 1960-2012, fiind evaluate: a) cuvintele cheie "S şi P"; b) fiecare an din 1960-2012; c) câteva dintre filtrele PubMed. B) Perioada 2010-2012, fiind evaluate: a) cuvintele cheie „S", „P", „S şi P"; b) câteva tipuri de P; c) fiecare tip analizat de P în combinaţie cu S. Evaluarea statistică s-a făcut pe baza testului Student.

Rezultate. Există diferenţe semnificative între mediile pe 52 ani: pentru numărul total de publicaţii (T), respectiv de abstracte şi de text integral, comparativ cu cel cu text integral gratuit (TIG); între vârstele 19-44 şi 65-plus, 19-plus şi 45-64, 19-plus şi 65-plus; între limba engleză şi alte limbi; între Articol de Journal (AJ) - Randomised controlled trial. În 2010-2012, numărul de publicaţii pentru „S" şi „P" este semnificativ crescut, comparativ cu cel pentru „S şi P"; numărul pentru fiecare „tip de P" este mai mare decât pentru „S şi fiecare tip de P".

Concluzii. 1) Numărul total de publicaţii pe 52 de ani este redus, 35. 2) Numărul de publicaţii cu TIG, este redus comparativ cu T, ceea ce ar putea fi un impediment pentru consultarea detaliilor de către cei cu posibilităţi financiare modeste, dar, limba de publicare a rezumatelor fiind engleza, accesul la informaţia sumară este facilitat. 3) Au fost preferate studiile cu subiecţi umani, bărbaţi, între 19-44 ani. 4) Tipul de publicaţie cel mai frecvent ales, dintre cele selectate, este AJ. 5) Studiile pentru „S

şi P" sunt diversificate pe mai multe tipuri ale P, din 17 pentru 2010-2012, 16 au concluzii favorabile utilizării P în S. 6) Relaţia S-P, deşi sumar reprezentată numeric, este importantă prin valoarea individuală a S şi P, dar şi prin deschiderea interesului acordat utilizării P în S.

Cuvinte cheie: sport, polifenoli, tipuri de polifenoli, filtre PubMed.

Introduction

Phytochemicals act as a defense system against diseases. They are natural bioactive compounds found in fruits, vegetables, aromatic and medicinal plants, flowers, leaves and roots (Vasanthi et al., 2012). Plant polyphenols have antiinflammatory, immunomodulatory and antioxidant effects (Bao et al., 2012). It has been proven that the antioxidant supplement offers protection against exercise-induced oxidative stress (Morillas-Ruiz et al., 2006). For their beneficial effects, polyphenols have been intensively studied in recent years (Mar et al., 2012), particulary those derived from green tea, termed green tea polyphenols (GTP) (Khan & Mukhtar, 2012). The relationship between polyphenols and sport has been investigated, but much less compared to other topics related to the subject of polyphenols. Thus, a recent study has demonstrated that caffeic acid stimulates skeletal muscle AMPK activity and insulin-independent glucose transport with a reduction of the intracellular energy status (Tsuda et al., 2012). Lengthening contraction-induced muscle injury is protected by apple polyphenols (APPs) (Nakazato et al., 2012). Regarding green tea extract (GTE) as a source of energy in skeletal muscle during exercise, increased metabolic capacity and utilization of fatty acid partly mediate its endurance-improving effects (Murase et al., 2012).

Hypothesis

Polyphenols are a topic of increasing interest in interdisciplinary research over recent years. Sport, in its turn, is a research topic of high interest. However, the relationship between the two subjects has been little investigated so far.

Objectives

The purpose of the present paper is the evaluation of research concerning the relationship between sport and polyphenols, by the retrospective analysis of PubMed publications over the past 52 years.

Material and methods

A. Analysis of 52 years, 1960-2012

The relationship between sport and polyphenols was carried out using three elements of analysis:
- key words "sport and polyphenols";

- each year of the period 1960-2012;
- some of the filters to check information provided by PubMed, whose names were those mentioned by the site, namely: *Text availability*, *Species*, *Sex*, *Ages*, *Languages*, *Article types*, each of these filters forming a study group.

Within each selected check filter, some subfilters were analyzed, and for each of them the number of publications per year was calculated, using the mentioned key words.
- For group filter *Text availability*, the chosen subfilters were: the total number of publications (T), the abstract number (AB), the number of publications with full text (FT) and free full text (FFT).
- For group filter Species, the chosen subfilters were: other animals (AN) and humans (H).
- For group filter Sex, the chosen subfilters were: Male (M), Female (F), Male and Female (MF).
- For group filter Ages, the chosen subfilters were: 0–18, 19–plus, 19-44, 45-64, 65-plus, 80-plus.
- For group filter *Languages*, the chosen subfilters were: English (E) and all the other languages (AL).
- For group filter *Article types*, the chosen subfilters were: Journal article (JA), Clinical trial (CT), Randomised controlled trial (RCT).

B. Analysis of the recent period 2010-2012

The relationship between sport and polyphenols was carried out using three elements of analysis:
- key words "sport" (S), "polyphenols" (P), "sport AND polyphenols" (S+P), "(some type of) polyphenols" and "sport AND (some type of) polyphenols";
- each year of the period 2010-2012;
- the polyphenols in the enter search box: Dietary (DT), Cocoa (CP), Coffee (CFP), Apple (AP), Grapes (GP), Plant (PP), Tea (TP), Green Tea (GTP).

Statistical evaluation was made on the basis of the Student's t-test.

Results

Data were collected in November 2012. For all groups, data distribution was normal, according to the Kolmogorov-Smirnov test. The analysis was performed on the chosen time periods.

A. Analysis of 52 years, 1960-2012

Analysis of the number of publications with the *Text availability* filter (Table I, Fig. 1). The total number of publications over the 52 years was 35 (T), followed by AB (33), representing 94% of T. The 52 year averages

Table I

Analysis of the number of publications with the *Text availability* filter.

Subfilter	Arithmetic mean	Standard deviation	p	Total number of publications (T)/52 years	% of T
Total (T)	3.1818	2.4827	0.004	35	100
Free full text (FFT)	0.6364	0.809		7	20
Abstract (AB)	3	2.5584	0.006	33	94
Free full text (FFT)	0.6333	0.7715		7	20
Full text (FT)	2.9083	2.5029	0.007	32	91
Free full text (FFT)	0.6333	0.7715		7	20

presented significant differences between T-FFT (p = 0.004), AB-FFT (p = 0.006), FT-FFT (p = 0.007). The dynamic analysis of the number of publications over the 52 years proves that T, AB and FT began to grow in the years 1989, 1990. Between 1991-2005 there were no publications, their number increased in subsequent years with a maximum value in 2010, and slightly decreased over the past two years. In 2012, FT was reduced compared to AB, but insignificantly.
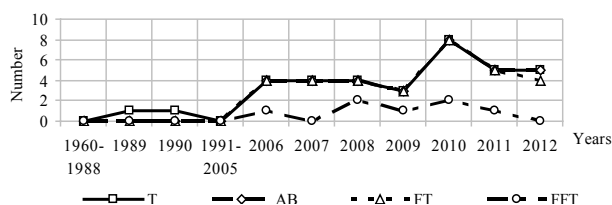

Fig. 2 – Dynamic analysis of the number of publications with the *Species* filter.

Fig. 1 – Dynamic analysis of the number of publications with the *Text availability* filter.

Analysis of the number of publications with the *Species* filter (Table II, Fig. 2). The total number of publications over the 52 years was the highest for H (21), representing 60% of T. Between the average number of publications for animal (AN) and human (H) there were no significant differences. There were no AN studies for the years 1960-1988 and 1990-2005 and no H studies for the years 1960-1989 and 1991-2005. The largest number of AN publications was in 2010 and of H publications in 2010-2011. Although insignificant, the greatest difference between the number of AN and H publications was found in 2011.
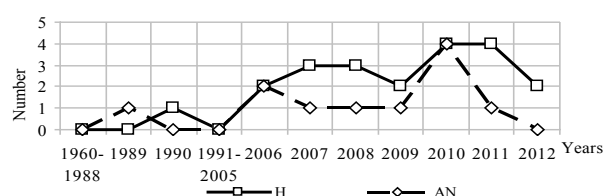
Analysis of the number of publications with the *Sex* filter (Table III, Fig. 3). The total number of publications over the 52 years was the highest for M+F (22), representing 62% of T. There were no significant differences between the average number of publications for male (M), female (F) and male and female (MF). The subjects' gender was not mentioned at all in studies over the years 1989 and 1990. The number of publications with M was greater compared to F in 2006-2008, 2010, 2011, but the differences were not significant. Although insignificant, the greatest difference between the number of publications with M and F was recorded in 2006.
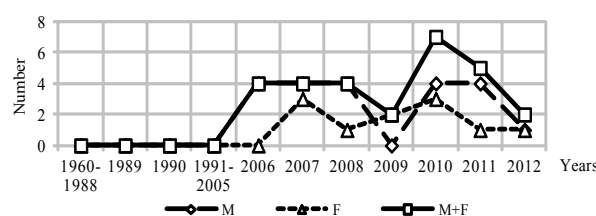

Fig. 3 – Dynamic analysis of the number of publications with the *Sex* filter.

Table II

Analysis of the number of publications with the *Species* filter.

Subfilter	Arithmetic mean	Standard deviation	p	Total number of publications (T)/52 years	% of T
Human (H)	1.9091	1.5136	ns	21	60
Animal (AN)	1	1.1832		11	31

Table III

Analysis of the number of publications with the *Sex* filter.

Subfilter	Arithmetic mean	Standard deviation	p	Total number of publications (T)/52 years	% of T
Male (M),	1.9091	2.0226		21	60
Female (F)	1	1.1832	ns	11	31
Male (M) + Female (F)	2	2.569		22	62

Table IV

Analysis of the number of publications with the *Ages* filter.

Subfilter	Arithmetic mean	Standard deviation	p	Total number of publications (T)/52 years	% of T
19-44	1.0909	1.0445	ns	12	34
45-64	0.5455	0.6876		6	18
19-44	1.0909	1.0445	0.04	12	34
65-plus	0.4545	0.5222		5	14
19-plus	1.6364	1.3618	0.04	18	51
45-64	0.5455	0.6876		6	18
19-plus	1.6364	1.3618	0.006	18	51
65-plus	0.4545	0.5222		5	14

Analysis of the number of publications with the *Ages* filter (Table IV, Fig. 4). The total number of publications over the 52 years was the highest for the 19-plus age group (18), representing 51% of T. There were no significant differences between the 19-44 and 45-64 age groups. In contrast, there were significant differences between 20-44 and 65-plus (p=0.04), 19-plus and 45-64 (p=0.04), 19-plus and 65-plus (p=0.006) age groups. There were no studies at all for the 0-18 and 80-plus age groups between 1960-2012; for the 44-64 and 65-plus age groups between 1960-2007; and for the 19-44 age group in 2009. For the study published in 1989, the age group used is not mentioned in the filter. The most numerous are the studies for the 19-plus age group. The greatest differences were recorded in 2011, between 19-plus and 44-65, and 65-plus age groups, respectively.
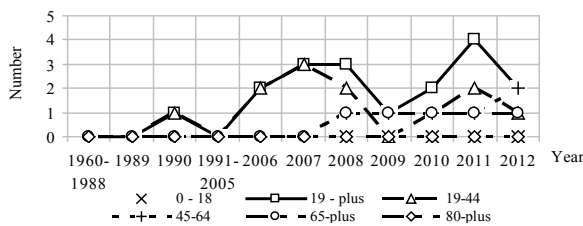

Fig. 4 – Dynamic analysis of the number of publications with the *Ages* filter.

Analysis of the number of publications with the *Languages* filter (Table V, Fig. 5). The total number of publications over the 52 years was the highest for E (33), representing 94% of T. There were significant differences between E and AL (p=0.003). The only language publication other than English was Russian, with one article published only in this language in 1989 and one article in 1990. The year with the most numerous mentions of English as a subfilter is 2010.
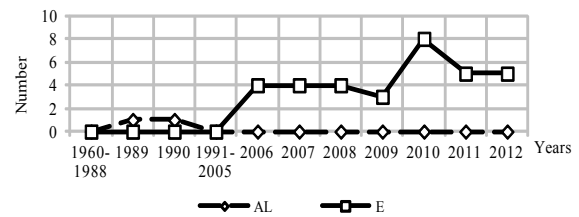

Fig. 5 – Dynamic analysis of the number of publications with the *Languages* filter.

Analysis of the number of publications with the *Article types* filter (Table VI, Fig. 6). The total number of publications over the 52 years was the highest for JA (32), representing 91% of T. There were no significant differences between JA-CT and CT-RCT. The JA-RCT difference was significant (p=0.05). By comparing the three subfilters, most of the publications were mentioned as JA, followed in descending order by CT, and RCT. The greatest difference between the number of publications was found for 2010, between JA-RCT (p=0.05), as well as between CT-RCT. In 2012, the number of publications with JA, CT and RCT subfilters was equal.
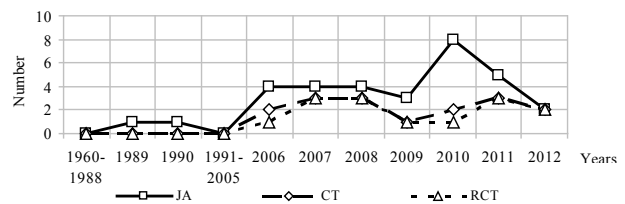

Fig. 6 – Dynamic analysis of the number of publications with the *Article types* filter.

B. Analysis of the recent period 2010-2012

For each year of the period 2010-2012, most of the publications were: in 2010, for S+P; in 2011, for S and for P. The highest total number of publications (TN) during the reporting period 2010-2012 was found for S (30725) (Table VII). TN for P and S+P was 10.2% and 0.6%, respectively, of S (Fig. 7).

Table V

Analysis of the number of publications with the *Languages* filter.

| Subfilter	Arithmetic mean	Standard deviation	p	Total number of publications (T)/52 years	% of T
Russian (AL)	0.1818	0.4045	0.003	2	5.8
English (E)	3	2.6833		33	94

Table VI

Analysis of the number of publications with the *Article types* filter.

Subfilter	Arithmetic mean	Standard deviation	p	Total number of publications (T)/52 years	% of T
Journal article (JA)	2.9091	2.4271	ns	32	91
Clinical trial (CT)	1.4545	1.2933		16	46
Clinical trial (CT)	1.4545	1.2933		16	46
Randomised controlled trial (RCT)	1.2727	1.2721	ns	14	40
Journal article (JA)	2.9091	2.4271		32	91
Randomised controlled trial (RCT)	2.9091	2.4271	0.05	14	40

Table VII

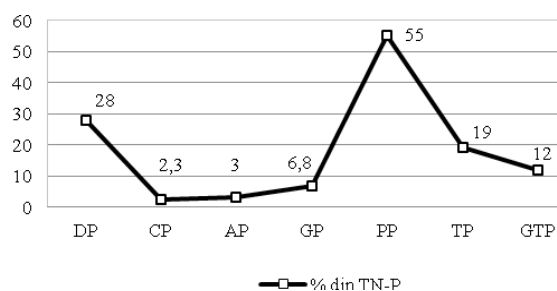Analysis of the number of publications during the 2010-2012 period.

Years	S	P	S+P
2010	10521	1011	8
2011	11255	1108	5
2012	8949	1024	5
TN (2010 + 2011 + 2012)	30725	3143	18

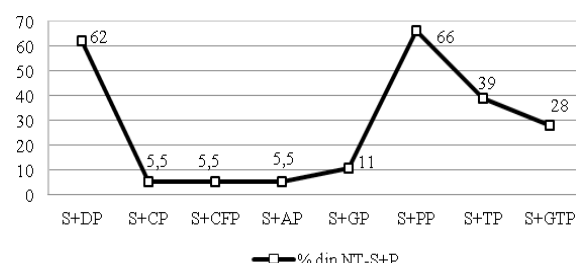Legend: key words "sport" (S), "polyphenols" (P), "sport AND polyphenols"(S+P).
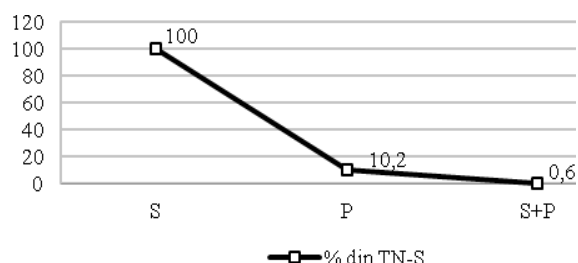
Fig. 7 – Analysis of % of TN-S for the number of publications during the 2010-2012 period, having as key words S, P and S+P.

For each year of the period 2010-2012, most of the publications were: in 2010, for CP; in 2011, for DP, AP, GP, PP, TP and GTP (Table VIII). Of the types of polyphenols shown in the search, the highest number was found for "plant polyphenols" (1738), representing 55% of TN-P, and the lowest for "coffee polyphenols", representing 1.8% of TN-P (Fig. 8).

Fig. 8 – Analysis of % of TN-P for the number of publications during the 2010-2012 period, having as key words DP, CP, AP, GP, TP, GTP.

For each year of the period 2010-2012, most of the publications were: in 2010, for S+DP, S+AP and S+PP; in 2011, for S+CP and S+TP (Table IX). For the combination of "sport AND (some kind of) polyphenol", TN was the highest for "sport AND plant polyphenols" (12), accounting for 66% of S+P , and the lowest for "sport AND cocoa polyphenols", "sport AND coffee polyphenols" and "sport AND apple polyphenols", representing 5.5% of S+P (Fig. 9).

Fig. 9 – Analysis of % of TN-P for the number of publications during the 2010-2012 period, having as key words S+DP, S+CP, S+CFP, S+AP, S+GP, S+TP, S+GTP.

A comparative analysis of the three years, 2010-2012, with regard to the publishing details and the findings relating to the use of P, provides some information (Table X). One of the articles was mentioned twice (Jówko et al.), so the total number is not 18, the display of the search, but 17. Of the 17 studies, only one has an unfavorable result. All studies are published in journals with an impact factor higher than 1.9, values ranging between 1.974 (Nutr Res.) and 7.036 (Environ Health Prev Med). In five cases, the first author was found in 2 abstracts: Andersson et al., Jówko et al., Ogasawara et al., Sakurai et al., Shen et al.

Discussion

Rationale for subfilters

Group filter *Text availability*. The rationale for the T, AB, FT, FFT subfilters choice is that the information choosing steps start with the title of the publication, continue with the reading of the summary, and then, depending on

Table VIII

Analysis of the number of publications during the 2010-2012 period.

Years	DP	CP	CFP	AP	GP	PP	TP	GTP
2011	289	26	15	32	62	601	197	128
2011	309	23	16	40	80	680	212	133
2012	289	24	27	21	73	457	175	101
TN (2010 + 2011 + 2012)	887	73	58	93	215	1738	584	362

Legend: key words "dietary polyphenols" (DP), "cocoa polyphenols" (CP), "apple polyphenols"(AP), "grapes polyphenols" (GP), "plant polyphenols" (PP), "tea polyphenols" (TP), "green tea polyphenols" (GTP).

Table IX

Analysis of the number of publications during the 2010-2012 period.

Years	S+DP	S+CP	S+CFP	S+AP	S+GP	S+PP	S+TP	S+GTP
2010	6	0	0	1	1	6	2	1
2011	3	1	0	0	1	5	3	2
2012	2	0	1	0	0	1	2	2
TN (2010 + 2011 + 2012)	11	1	1	1	2	12	7	5

Legend: key words "sport AND dietary polyphenols" (S+DP), "sport AND cocoa polyphenols" (S+CP), "sport AND coffee polyphenols" (S+CFP), "sport AND apple polyphenols"(S+AP), "sport AND grapes polyphenols" (S+GP), "sport AND tea polyphenols" (S+TP), "sport AND green tea polyphenols" (S+GTP).

Table X

Comparative analysis of 2010-2012, with regard to the publishing details and the findings relating to the use of P.

Year and month of publication	Journal	Journal impact factor 2011	P type referred to as key word	Conclusion Favorable (F) Unfavorable (UF)	Authors
2012 Dec	Int J Sport Nutr Exerc Metab	2.01	GTP, TP	UF	Jówko et al.
2012 Nov	J Nutr Biochem	3.891	Cofee P	F	Tsuda et al.
2012 Sep	Environ Health Prev Med	7.036	DT	F	Sakurai et al.
2012 Jul	Phytomedicine	3.268	PP	F	Ulrich-Merzenich et al.
2012 May	Osteoporos Int	4.58	GTP, TP, DT, PP	F	Shen et al.
2012 Jan	Med Sci Sports Exerc	4.431	Non-alcoholic beer (NAB), DP	F	Scherr et al.
2011 Sep	Clinics (Sao Paulo)	2.058	GP, DP, PP	F	Gonçalves et al.
2011 Nov	Nutr Res	1.974	GTP, TP, DP, PP	F	Jówko et al.
2011 Apr	Int J Sport Nutr Exerc Metab	2.01	CP, PP	F	Allgrove et al.
2011 Mar	Phytother Res	2.086	GPT, TP, Oligonol = lychee fruit-derived, PP	F	Ogasawara et al.
2010 Dec	BMC Complement Altern Med	2.241	GTP, TP, DP, PP	F	Shen et al.
2010 Dec	J Appl Physiol	3.753	Purple sweet potato leaves (PSPL), DP, PP	F	Chang et al.
2010 Nov	Biochem Biophys Res Commun	2.484	Oligonol = lychee fruit-derived, DP	F	Ogasawara et al.
2010 Nov	Br J Nutr	3.013	DP	F	Andersson et al.
2010 Aug	Scand J Med Sci Sport	3.867	DP	F	Andersson et al.
2010 Mar	Mol Nutr Food Res	4.301	AP, DP, PP	F	Nakazato et al.
2010 Jan	J Nutr Biochem	3.891	GP, DP, PP	F	Sakurai et al.

interest, with the full text. There are publications that are not accompanied by an abstract, especially in the early years of the PubMed website. In addition, most publications allow for full text purchase, and this is a difficulty for those who would like to be informed but have modest financial possibilities. For them, free full text publications are a real help.

Group filter *Species*. The rationale for subfilters AN and H starts from the idea that the studies referring to polyphenols and sports are both clinical and experimental. The choice of one or other of these subfilters is useful in selecting studies.

Group filter *Sex*. The rationale for M, F, MF subfilters is based on the fact that there may be sex differences in the results of studies on polyphenols and sport. Some of these studies include in the analyzed groups only one gender, other studies, both genders.

Group filter *Ages*. The rationale for filters 0-18, 19-plus, 19-44, 45-64, 65-80 is related to finding that the body's reactions differ from an age group to another. This study shows that, for the chosen key words, there are no publications that contain extreme age groups, i.e. 0-18 and over 80.

Group filter *Languages*. The rationale for subfilters E and AL has as a motivation the fact that although English is the language used for abstracts, the language of the full text publication can sometimes be the native author's language. This is good to know when someone wants to consult full text articles, especially those that are free.

Group filter *Article types*. The rationale for subfilters JA, CT and RCT is that these types of publications have proved to be among the most frequently used publishing options.

Intra-group analysis

Group filter *Text availability*. The dynamic evolution of T, AB and FT proves that between 1960-2005, i.e. for 45 years, studies on "sport and polyphenols" were very few, including only one article in 1989 and another one in 1990. The interest in this subject began to grow in 2005-2006, the number of publications amounting to four per

year in the years 2006, 2007, 2008. Over 52 years, the maximum number of publications per year was eight, in 2010. In the past two years it reached five publications per year, with these key words. Of these publications, for 45 years, between 1960-2005, in 2007 and 2012, FFT were non-existent. In the years 2008 and 2010, there were two FFT for each year, for these key words.

Group filter *Species*. The dynamic evolution of AN and H proves that between 1960-2005, i.e. for 45 years, studies on "sport and polyphenols" were very few, including one article for AN in 1989 and another one for H, in 1990. In 2006 and 2010, the number of publications was equal for AN and H, two for each year. Starting with 2007, the number of publications on human subjects was permanently higher compared to those on animal subjects. In 2012, there were no animal studies until the time of the collection of PubMed data. These findings show that regarding the "sport and polyphenols" subject, clinical trials were preferred.

Group filter *Sex*. The dynamic evolution of M, F and MF proves that between 1960-2005, i.e. for 45 years, there were no mentions of these subfilters in studies on "sport and polyphenols". Studies on the selected key words began to mention these filters in 2006, and since then, with the exception of 2009, the studies that included M outnumbered the ones that included F. In 2006, the number of the studies was four, containing only M, and in 2009, their number was two, containing only F. We notice that in the case of studies that have "sport and polyphenols" as key words, M subjects were preferred.

Group filter *Ages*. The dynamic evolution of the selected age groups as subfilters proves that between 1960-2005, i.e. for 45 years, studies on "sport and polyphenols" were very few, only two articles being published in 1989, one for the 19-plus and the other one for the 19-44 age group. However, considering that the first subfilter includes the second one, there is actually a single publication. The years 2007, 2008 and 2011 were those that mentioned the subfilters most frequently, three studies for each year. In 2012, until the time of the collection of Pubmed data, there was one published study with respondents aged between 18-44 years, one study for the 65-plus age group and two

studies for the 45-64 age group. The most frequent age range of studies on this topic was 19-44. As a result, we might make some assumptions: within this age range, sport is more frequently practiced; the use of polyphenols is the most necessary or the most effective or with the most well-defined results during this period of life; in this age group, study cooperation is optimal.

Group filter *Languages*. The dynamic evolution of E and AL proves that between 1960-2005, i.e. for 45 years, studies on "sport and polyphenols" were very few, only one article being published in 1989 and another one in 1990, both in Russian. Since 2004, the language of the publication began to appear as the filter, the only subfilter being English. We can deduce that, at least at the beginning, the studies with the key words "sport and polyphenols" were conducted by Russian researchers. The use of English in most publications can be justified by the need for an international language, to facilitate access to information.

Group filter *Article types*. The dynamic evolution of JA, CT and RCT proves that between 1960-2005, i.e. for 45 years, studies on "sport and polyphenols" were very few, one article being published in 1989 and another one in 1990, both for JA. Of the selected subfilters, the most frequently mentioned one was JA, with an equal number of publications in 2006, 2007 and 2008, four each year, and a maximum number in 2010, amounting to eight. CT and RCT mentions were permanently fewer compared to JA. It can be inferred that at least among the three analyzed subfilters, JA is the most used form of publication.

The recent period 2010-2012

The multiple beneficial effects of different types of polyphenols, supported by numerous studies, represent a starting point for their use in the field of sport.

The present study shows a large number of publications that match the search key words "sport" (TN=30725) and "polyphenols" (TN=3143), proving the interest in these two research topics, at least for the last three years. The appropriate search for the group of two terms "sport AND polyphenols" shows a greatly reduced number of publications (TN=17) compared with S and P. This situation could be explained by the fact that the studies concerning the use of polyphenols in sport could still be in their infancy. To support this hypothesis, there are 18 studies with S + P, of which only one has unfavourable conclusions.

We cite, in short, the findings of studies on S+P, grouped by types of polyphenols mentioned in the abstract.

Dietary polyphenols

"Exercise training as well as intake of *supplements*, such as polyphenols, is one strategy for this, because this regimen can result in reduction of WAT (White adipose tissue) mass, which affects the expression and secretory response of adipokines" (Sakurai et al., 2012). "WB (*standardized willow bark preparation*) (30 mg/kg), its ethanolic fraction rich in salicyl alcohol derivatives (FR-D) (30 mg/kg) and imipramine, by being effective in the FST (forced swimming test), modulated known and new targets relevant for neuro- and immunofunctions in rats" (Ulrich-Merzenich et al., 2012). "Intermittent exercise in well-trained female athletes is effectively balanced by the recruitment of both *endogenous and dietary* antioxidants, resulting in the absence of lipid peroxidation" (Andersson et al., 2010 a). "The soccer-associated dietary antioxidant defence, but not the *endogenous* antioxidant defence, is persistent" (Andersson et al., 2010 b). "Consumption of 1-1.5 L · d(-1) of NAB (*nonalcoholic beer*) for 3 wk before and 2 wk after marathon competition reduces postrace inflammation and URTI (upper respiratory tract illness) incidence" (Scherr et al., 2012). "That oligonol (a *lychee fruit*-derived low-molecular form of polyphenol) activates the Ras/Raf-1/MEK (MAPK/ERK kinase) 1/2 signaling pathway, independent of the IL-6 signaling pathway, leading to activation of ERK (phosphorylated extracellular-signaling regulatory kinase) 1/2 proteins in primary adipocytes" (Ogasawara et al., 2010). "Consuming a high-polyphenol diet (*purple sweet potato leaves (PSPL)*) for 7 days can modulate antioxidative status and decrease exercise-induced oxidative damage and pro-inflammatory cytokine secretion" (Chang et al., 2010).

Cocoa polyphenols

"Regular DC (*dark chocolate*) intake is associated with reduced oxidative-stress markers and increased mobilization of free fatty acids after exercise but has no observed effect on exercise performance" (Allgrove et al., 2011).

Coffee polyphenols

"*Caffeic* acid but not chlorogenic acid acutely stimulates skeletal muscle AMPK (5'-adenosine monophosphate-activated protein kinase) activity and insulin-independent glucose transport with a reduction of the intracellular energy status." (Tsuda et al., 2012).

Apple polyphenols

"Dietary APPs (*apple* polyphenol) have protective effects against lengthening contraction-induced muscle injury" (Nakazato et al., 2010).

Grapes polyphenols

"D organic *grape* juice has a positive effect in endurance athletes" (Gonçalves MC et al., 2011). "The antioxidative properties of OGSP (oligomerized *grape* seed polyphenol) attenuate inflammatory changes induced by the coculture of adipocytes and macrophages" (Sakurai et al., 2010).

Tea polyphenols

"The coordinated direct effect of *mixed polyphenol*, which comprises oligonol, on ERK (extracellular signalling-related kinase) 1/2 plays a key role in a greater lipolytic response to oligonol than EGCG (*tea* (-)-epigallocatechin-3-gallate) alone" (Ogasawara et al., 2011).

Green tea polyphenols

"Acute ingestion of *GTP* (640 mg) does not attenuate exercise-induced oxidative stress and muscle damage" (Jówko et al., 2012). "*GTP* supplementation, TC ((ai Chi) exercise, and the combination of the two all improved muscle strength in postmenopausal women with osteopenia" (Shen et al., 2012). "On previously untrained men, dietary supplementation with GTE (*green tea* extract) (in combination with strength training) enhances the antioxidant defense system in plasma at rest and, in turn, may give protection against oxidative damage induced by both short-term muscular endurance test and long-term strength training" (Jówko et al., 2011). "*GTP* at a dose of 500 mg/day and/or TC exercise at 3 hr/week for 24 weeks

appear to be safe in postmenopausal osteopenic women, particularly in terms of liver and kidney functions" (Shen et al., 2010).

The analysis of the favorable conclusions for S+P over the years 2010-2012 demonstrates the efficiency of the use of polyphenols in various forms of sport, with beneficial effects on the body, of which the most important are antioxidant, antiinflammatory effects, as well as those on adipose tissue. Although the number of publications for S+P is small and the researchers involved are few, the results obtained are encouraging.

Conclusions

1. The study, although analyzing a long time period, 52 years, totals a small number of publications, 35.

2. The number of publications with free full text is low compared to the total number of articles, which could be an impediment to consult the details for those with modest financial possibilities,

3. For a group of selected key words, the favorite studies were in human subjects, especially men, mostly aged between 19-44 years.

4. The most commonly chosen publication type of those selected is the journal article item.

5. Studies on sport and polyphenols are diversified across several types of polyphenols, and out of a total number of 17 studies, with the search combination "sport AND polyphenols", found for the 2010-2012 period, 16 have favorable conclusions for the use of polyphenols in sports.

6. Although the number of publications for the "sport AND polyphenols" combination is reduced, and the researchers involved are numerically few, the relationship between sport and polyphenols is important by the value of the two subjects and the published results may be regarded as encouraging for further study in this research direction.

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