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Rhodiola rosea's relationship with stress, physical fatigue and endurance; a PubMed evaluation

Relaţia Rhodiolei rosea cu stresul, oboseala fizică şi anduranţa; o evaluare PubMed

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Abstract

Background. Rhodiola rosea is a well-known adaptogen, and among its actions are those of antistress and anti-fatigue protection.

Aims. The aim of the present research is the evaluation of the number of PubMed publications regarding Rhodiola rosea's (RR) relationship with stress (S), physical fatigue (F) and endurance (E).

Methods. Analysis was performed: a) for specific selected keyword combinations (KWC): "RR" (RR), "RR and stress" (R+S), "RR and cortisol" (R+C), "RR and anxiety" (R+A),"RR and physical fatigue" (R+F),"RR and endurance" (R+E); and for some filter and subfilters provided by the PubMed site.

Results. A) *Analysis of the number of publications* (N). For RR, we found the largest: period of publication (54 years), N (743), average number of publications per publication period (13.76). Relative to RR, the highest % was for R+S (23.28%). B) *Analysis of filters.* a) *Text availability*. The percentage of the number of abstracts (A) was high and close to the coresponding N (NC). The highest % of RR was for R+S in A (23.52%), full text (FT) (27.8%) and free full text (FFT) (27.23%). b) *Species.* The highest number was for RR, both in animals (An) (322) and humans (H) (211). The highest % of RR was for R+S, both in An (24.53%) and H (32.7%). c) *Sex.* The highest number was for RR in H males (HM) (60), H females (HF) (45) and H males+females (HM+F) (74). The highest % of RR was for R+S in HM (28.33%), HF (31.11%) and HM+F (29.73%).

Conclusions. 1) The number of publications for the KWC differed; it was the largest for RR and R+S, smaller for R+F and R+E, and the smallest for R+A and R+C. 2) For all KWC, the number of FFT publications was reduced compared to the total number of publications, the number of A and FT, with a predominance of FFT for R+C as a percentage of NC. 3) Apart from RR and R+S, in which animal research predominated, for all the other chosen KWC, research on human subjects was preferred. 4) Apart from R+F, in which research on females predominated, for all the other chosen KWC, research on subjects of both genders was preferred.

Keywords: Rhodiola rosea, stress, cortisol, anxiety, physical fatigue, endurance, adaptogen, PubMed filters

Rezumat

Premize. Rhodiola rosea este un binecunoscut adaptogen şi printre acţiunile sale se numără şi cele de protecţie antistress şi anti-oboseală.

Obiective. Scopul prezentei cercetări este evaluarea numărului de publicaţii PubMed privind relaţia dintre Rhodiola rosea (RR) şi stresul (S), oboseala fizică (F) şi rezistenţa (E).

Metode. Analiza a fost efectuată: a) pentru combinaţii specifice de cuvinte cheie selectate (CCC): "RR" (RR), "RR şi stres" (R+S), "RR şi cortizol" (R+C) "RR şi anxietate" (R+A), "RR şi oboseală fizică" (R+O), "RR şi anduranţă" (R+D); şi pentru unele filtre şi sub-filtre furnizate de site-ul PubMed.

Rezultate. A) *Analiza numărului de publicaţii* (N). Pentru RR, s-a constatat: cea mai mare perioadă de publicare (54 ani), cel mai mare N (743), număr mediu de publicaţii pe perioadă de publicare (13,76). În raport cu RR, cel mai mare procent a fost pentru R+S (23,28%). B) *Analiza filtrelor.* a) *Filtrul Disponibilitatea textului.* Procentul pentru numărul de rezumate (A) a fost ridicat şi aproape de N corespunzător (NC). Cel mai mare % din RR a fost pentru R+S, la A (23,52%), text integral (FT) (27,8%) şi text complet gratuit (FFT) (27,23%). b) *Filtrul Specii.* Cel mai mare număr a fost pentru RR, atât la animale (An) (322), cât şi la oameni (H) (211). Cel mai mare % din RR a fost pentru R+S, atât la An (24,53%), cât şi la H (32,7%). c) *Filtrul Sex.* Cel mai mare număr a fost pentru RR, la bărbaţi (HM) (60), femei (HF) (45) şi bărbaţi+femei (HM+F) (74). Cel mai mare % din RR a fost pentru R+S, la HM (28,33%), HF (31,11%) şi HM+F (29,73%).

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Concluzii. 1) Numărul publicațiilor pentru CCC a diferit, fiind cele mai numeroase pentru RR și R+S, fiind mai puține pentru R+F și R+E, și cele mai reduse pentru R+A și R+C. 2) Pentru toate CCC, numărul de publicații cu text integral gratuit a fost redus comparativ cu totalul publicațiilor, cu numărul de abstracte și de texte integrale, predominând procentual față de NC publicațiile gratuite pentru R+C. 3) Cu excepția RR și R+S, la care au predominat studiile pe animale, pentru toate celelalte CCC alese au fost preferate studiile cu subiecți umani. 4) Cu excepția R+F, la care au predominat cercetările pentru genul feminin, pentru toate celelalte CCC alese au fost preferate cercetarile cu subiecți de ambele genuri.

Cuvinte cheie: Rhodiola rosea, stres, cortizol, anxietate, oboseala fizică, anduranță, adaptogen, filtre PubMed

Introduction

Rhodiola rosea (RR), also known as golden root, is an adaptogenic plant, which is capable of increasing the body's resistance to a variety of physical, chemical, biological and psychological stress factors, in a non-specific way (Amsterdam & Panossian, 2016).

Stress (S). S affects multiple brain regions (Shields et al., 2016), and the response to S determines an appropriate release of S-related hormones (Lupien et al., 2007). The uncertainty about an uncontrollable negative event tends to provoke S responses, anxiety behavior and neuronal activity (Herry et al., 2007). Anxiety is a response to S, which involves physiological, emotional and cognitive changes (Robinson et al., 2013).

Rhodiola rosea for stress, physical fatigue and endurance. Due to its central nervous system stimulation action (Baker et al., 2014), RR reduces anxiety (Cropley et al., 2015). The anxiolytic effect of RR extracts was demonstrated both in animals (Perfumi & Mattioli, 2007) and humans (Spasov et al., 2000). RR also reduces S-related fatigue (Walker & Robergs, 2006), which incorporates physical, emotional and mental exhaustion (Olsson et al.2009). In this sense, it is known that in Siberia, RR was used, among others, to increase physical strength and to treat fatigue (Khanum et al., 2005). As an example of its practical use, Rhodaxon, a preparation containing RR, decreases situational anxiety and mental fatigue (Spasov et al., 2000), and a 400 mg daily dose of RR ethanol extract may be an effective treatment in subjects suffering from prolonged or chronic fatigue (Lekomtseva et al., 2017). An explanation for the anxiolytic and anti-fatigue effects would be the presence of salidroside, a major active ingredient of RR, well known for its actions on psychological stress and fatigue (Zhang et al., 2017). RR intake can also improve endurance in humans and rats (Walker & Robergs, 2006). These effects can be explained by the fact that RR activates synthesis or resynthesis of ATP in mitochondria, and stimulates repairing energy processes after intense exercise (Abidov et al., 2003). Modulation of endurance can be achieved with RR extract, not just in chronic RR administration, as was the case in swimming exercise (Lee et al., 2009), but also in acute RR administration, for example in healthy young volunteers (De Bock et al., 2004). Acute RR ingestion "decreases heart rate response to submaximal exercise and appears to improve endurance exercise performance by decreasing the perception of effort" (Noreen et al., 2013).

The present article is the continuation of previous research of the authors concerning adaptogens - Ginseng (Jurcău et al., 2013a), Schisandra chinensis (Jurcău et al., 2013b) and Rhodiola rosea (Jurcău et al., 2012a) and also, the relationship between stress and physical effort (Jurcău et al., 2012b; Jurcău & Jurcău, 2013c; Jurcău & Jurcău, 2017).

Hypothesis

Rhodiola rosea is a well-known adaptogen, and among its actions are those of antistress and anti-fatigue protection.

Objectives

The aim of the present research is the evaluation of the number of PubMed publications regarding Rhodiola rosea's (RR) relationship with stress (S), physical fatigue (F) and endurance (E).

Material and methods

The relationship between RR and S, F and E was analyzed for the following specific selected keyword combinations (KWC): "Rhodiola rosea" (RR), "Rhodiola rosea and stress" (R+S), "Rhodiola rosea and cortisol" (R+C), "Rhodiola rosea and anxiety" (R+A), "Rhodiola rosea and physical fatigue" (R+F), "Rhodiola rosea and endurance" (R+E).

In order to perform the analysis, the following filters and subfilters provided by the PubMed site were used: a) For the *text availability* filter, the chosen subfilters were: abstract (A), full text (FT) and free full text (FFT); b) For the *species* filter, the chosen subfilters were: other animals (AN) and humans (H); c) For the *sex* filter, the chosen subfilters (selecting at the same time the human subfilter) were: male (human+male = HM), female (human+female = HF), male and female (MF) (human+male+female = HMF); d) For the *age* filter, the chosen subfilters were: 0-18, 19-44, 45-64, >65, >80.

Evaluation was performed for a period of 54 years, from 1963 to 2017, and had the following elements of analysis: A) *Analysis of the total number of publications (N)*. The total number of publications corresponding to all chosen KWC (NC) was taken into account: N-RR, N-RS, N-RC, N-RA, N-RF, N-RE. B) *Analysis of the filters*. For all analyzed subfilters, for all selected KWC, the percentage (%) of the number of RR publications corresponding to each subfilter was taken into account.

Results

Data were collected in January 2018. For all groups, data distribution was normal, according to the Kolmogorov-Smirnov test. The analysis was made over the chosen time periods.

A. Analysis of the total number of publications (Table I, Fig. 1).

The longest period of publication (Table I) was 54

years (for RR), followed by 31 years (for R+S) and 28 years (for R+C), and the shortest period was 17 years (for R+A, R+F and R+E). The largest NC (Table I) was for RR (743), followed by R+S (173), and the lowest NC was for R+C (10). In the same numerical order (Table I), the average number of publications per publishing period was the largest for RR (13.76), followed by R+S (5.28), and the lowest for R+C (0.36). Relative to RR (Fig. 1), the highest % was represented by R+S (23.28%), followed by almost equal % for R+F and R+E (3.23%, 3.1%), and the smallest % was found for R+C (1.34%).

Table I

Total number of publications (N) for KWC and the corresponding publication period

KWC	Period	Years of publication	NC	Average N per year
RR	1963-2017	54	743	13.76
R+S	1986-2017	31	173	5.58
R+C	1987-2015	28	10	0.36
R+A	2000-2017	17	15	0.83
R+F	2000-2017	17	24	1.41
R+E	2000-2017	17	23	1.35

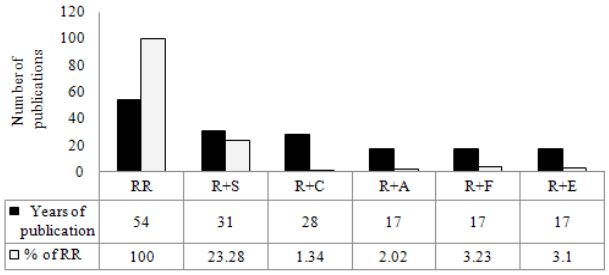


Fig. 1 - Analysis by years of publication of the% of RR, for each of the selected KWC

B. Analysis of the filters.

a) The text availability filter (Table II, Fig. 2). For all selected KWC (Table II), the percentage of the number of abstracts (A) was high and close to NC: for R+C, R+F and R+E, A was equal to NC (100%), and for R+A, it was the lowest (93.3% of N-RA). The number of publications for FT was lower than for A: the highest percentage was recorded for R+C (90% of N-RC) and the lowest percentage was found for RR (74.6% of N-RR). The fewest publications were for FFT, with a maximum for R+C (40% of N-RC) and a minimum for R+A (none). Compared to RR (Fig. 2): the highest % of RR was for R+S in A (23.52%), FT (27.8%) and FFT (27.23%); the lowest % of RR was in A and FT for R+C (1.4% and 1.62% respectively), and in FFT for R+A (0%).

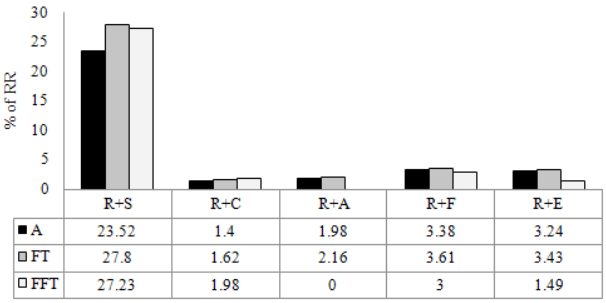


Fig. 2 - The percentage of RR for each of the selected KWC, for the subfilters of the *text availability* filter

b) The species filter (Table III, Fig. 3). For all selected KWC (Table III): the greatest number was for RR, both in An (322) and H (211), and the smallest number was for R+C, both in An (3) and H (7). For all selected KWC, the percentage of NC (Fig. 3): was the highest for R+A, both in An (46.7% of N-RA) and H (73.33% of N-RA), and the lowest in An for R+C (30% for N-RC) and in H for RR (28.4% of N-RR). Compared to RR (Fig. 3): the highest % of RR was found for R+S, both in An (24.53%) and H (32.7%); the lowest % of RR was recorded for R+C, both in An (0.93%) and H (3.23%).

Table III

The percentage of N for each of the chosen KWC, for the subfilters of the *species* filter

Period	KWC	NC	An	% An of N	H	% H of N
1963-2017	RR	743	322	43.3	211	28.4
1986-2017	R+S	173	79	45.6	69	39.9
1987-2015	R+C	10	3	30	7	70
2000-2017	R+A	15	7	46.7	11	73.3
2000-2017	R+F	24	10	41.7	16	66.7
2000-2017	R+E	23	9	39.1	14	60.9

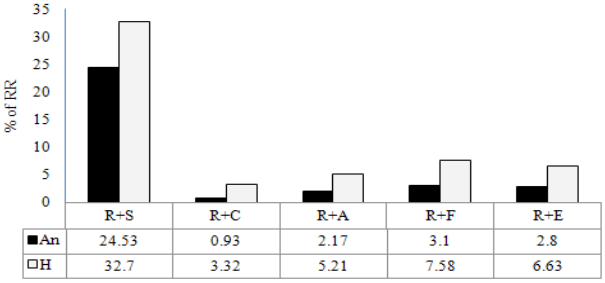


Fig. 3 - The percentage of RR for each of the selected KWC, for the subfilters of the *species* filter

Table II

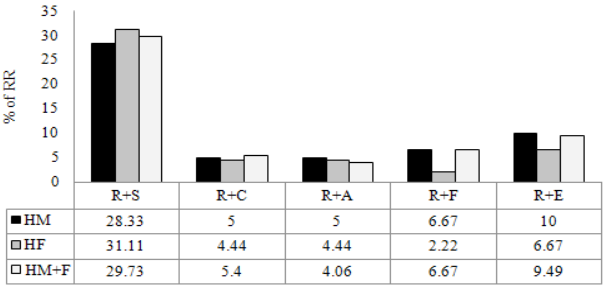
The percentage of N for each of the chosen KWC, for the subfilters of the *text availability* filter

Period	KWC	NC	A	% A of N	FT	% FT of N	FFT	% FFT of N
1963-2017	RR	743	710	95.56	554	74.56	202	27.19
1986-2017	R+S	173	167	96.53	154	89	55	31.8
1987-2015	R+C	10	10	100	9	90	4	40
2000-2017	R+A	15	14	93.33	12	80	0	0
2000-2017	R+F	24	24	100	20	83.3	6	25
2000-2017	R+E	23	23	100	19	82,6	3	13

Table IV
The percentage of N for each of the chosen KWC, for the subfilters of the *sex* filter

Period	KWC	NC	HM	% HM of N	HF	% HF of N	HM+F	% HM+F of N
1963-2017	RR	743	60	8.08	45	6.06	74	9.9
1986-2017	R+S	173	17	9.8	14	8.09	22	12.7
1987-2015	R+C	10	3	30	2	20	4	40
2000-2017	R+A	15	3	20	2	13.33	3	20
2000-2017	R+F	24	4	1.67	1	4.14	4	1.7
2000-2017	R+E	23	6	23.1	3	13.04	7	30.4

c) The sex filter (Table IV, Fig. 4). For all selected KWC (Table IV): the highest number was for RR in HM (60), HF (45) and HM+F (74), and the smallest number was for R+C and R+A in HM (3 for each), for R+F in HF (1), and for R+A in HM+F (3). For all selected KWC, the percentage of NC (Figure 3): was the highest for R+C in HM (30% of N-RC), HF (20% of N-RC) and HM+F (40% of N-RC), and the lowest for R+F in HM (1.67% of N-RF), HF (4.14% of N-RF) and HM+F (1.7% of N-RF). Compared to RR (Fig. 4): the highest % of RR was recorded for R+S in HM (28.33%), HF (31.11%) and HM+F (29.73%); the smallest % of RR was found for R+C and R+A in An (5% for each), for R+F in HF (2.22%), and for R+A in HM+F (4.06%).



	R+S	R+C	R+A	R+F	R+E
HM	28.33	5	5	6.67	10
HF	31.11	4.44	4.44	2.22	6.67
HM+F	29.73	5.4	4.06	6.67	9.49

Fig. 4 - The percentage of RR for each of the selected KWC, for the subfilters of the *sex* filter.

Discussion

Justification for choosing subfilters

The *text availability* group filter. A provides extremely useful information in order to have a brief idea about the content of the article concerned. There are publications without an A, especially in the early years of the PubMed website. Free full-text publications are a real help, but most publications offer full-text access by purchase, which poses difficulties for those who would like to be informed but have modest financial possibilities.

The *species* group filter. Studies that refer to RR, RR and stress, and RR and physical effort and endurance are both clinical and experimental. The choice of either one of these subfilters is useful in selecting studies.

The *sex* group filter. Depending on gender, there may be differences in the results of studies on RR, RR and stress, and RR and physical effort and endurance. Some of these studies include only one gender in the analyzed groups, while other studies include both males and females.

Analysis of the total number of publications

The total number of publications (Fig.1) proves that studies on RR, R+S and R+C began before 2000 (1963, 1986 and 1987, respectively) and continued until 2017 inclusive (except for R+C, until 2015 inclusive), and during these periods (54, 31, 59 and 28 years respectively), 743, 173 and 10 studies, respectively, were published; for R+A, R+F and R+E, publications started in 2000 and continued throughout 2017, and over these 17 years, 15, 24 and 23 studies were published. It should be noted that studies on R+C, although mentioned before 2000, are fewer (10) compared to R+A (15), R+F (24) and R+E (23) mentioned after 2000.

Considering the average per annum of publications, it can be seen that the highest interest was in RR (13.76/year), followed by R+S (5.58/year) and the lowest interest was in R+A (0.83/year) and R+C (0.36/year). Considering the % of N-RR, research interest was the highest in R+S (23.28%), followed by R+F (3.23%) and R+E (3.1%) at a distance. The lowest interest was in R+A (2.02%) and R+C (1.34%).

From the above, it can be observed that research on the Rhodiola rosea plant is generally predominant. This is understandable, given that all the other studies could be considered as integral parts of a whole, represented by RR. Of all RR studies, stress research was predominant, which is in agreement with the interest, from the beginning of RR use, in the increase of stress response. Cortisol and anxiety, considered markers of the body's response to stress (especially mental stress) are the least found in the PubMed search for RR presented in this article. The larger number of studies on RR and physical and endurance fatigue, twice the number of studies on cortisol and anxiety, can be justified by two hypotheses: a) RR has been used since its inception to reduce fatigue in general and increase the body's resistance to effort b) RR may be more useful in situations of physical effort and for modulating endurance than in modulating mental stress.

Analysis of filters

The text availability filter. It was shown that: A is present in the vast majority of publications, being 100% of NC for three combinations (R+C, R+F and R+E); the number of FT is lower compared to A, but higher than FFT; the number of FFT is lower compared to A and FFT. Therefore, the PubMed site displayed A for the vast majority of KWC publications. The most available publications that can be read for free are the ones related to RR, and among them, those related to R+C. It should be noted that although R+C publications are the lowest in number, they show the highest percentage of NC for FFT (40% of N-RC). For those who wish to read the full text, only a small part of the selected KWC publications are available free of charge on PubMed.

The species filter. Considering the percentage of NC, we found that research predominantly included: animals

for RR (43.3% of N-RR) and R+S (45.6% of N-RS); human subjects for the other KWC, in numerical order R+A (73.3% of N-RA), R+C (70% of N-RC), R+E (60.9% of N-RE). Animal studies were predominant for two KWC (RR, R+S), with publication periods starting before 2000, while publication of human studies started in 2000. Also, studies on humans were more related to topics involving psychological characteristics that can be predominantly assessed in human subjects - anxiety, physical fatigue, endurance. The tendency of the last 17 years to conduct RR research on the selected topics mainly in human subjects could be explained by the fact that the main purpose of RR use is for the benefit of people.

The sex filter. Considering the percentage of NC, we found a preference of research for subjects: HF for R+F only (4.14% of N-RF); HM+F for all other KWC, in numerical order: R+C (40% of N-RC), R+E (30.4% of N-RE), R+A (9.9% of N-RR). Both genders were studied in most of the RR research selected in this article. This may be a possible indication of the usefulness of this plant for both men and women, as well as of the interest in using RR for both sexes in stress situations, physical fatigue and modulation of endurance.

Conclusions

1. The number of publications for the searched KWC differed; it was the largest for RR and R+S, smaller for R+F and R+E, and the smallest for R+A and R+C.

2. For all KWC, the number of FFT publications was reduced compared to the total number of publications, the number of A and FT, with a predominance of FFT for R+C as a percentage of NC.

3. Except for RR and R+S, which evidenced a preponderance of animal research, for all the other chosen KWC, studies on human subjects were preferred.

4. Apart from R+F, which showed a predominance of the female sex, for all the other chosen KWC, research on subjects of both sexes was preferred.

Conflicts of interest

Nothing to declare.

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