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Research on the Development and Hot Spot of Delayed Muscular Soreness

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ABSTRACT. *based on the related research literature in the field of delayed muscle soreness collected in Web of science database from 2009 to 2019, the chart is drawn, the research hotspots and research trends in this field are summarized, and the dynamic changes in this field are analyzed. The results showed that the research on high output countries and institutions in the field of delayed muscle soreness was mainly concentrated in Europe and the United States and Australia. The hot spots in the field of research mainly include eccentric exercise, skeletal muscle, muscle injury, cold water immersion, inflammation and so on. From the point of view of research content, the study of delayed muscle soreness is important. The point is transitioning from mechanism to treatment. The focus of future research may be the prevention strategy of delayed muscle soreness and the influence of other interference factors on the formation of research muscle soreness and the rational use of the strategy.*

KEYWORDS: *muscle injury, exercise, skeletal muscle, inflammation, knowledge graph*

1 Introduction:

Delayed muscle soreness (DOMS) is a physiological response to muscle soreness that occurs after the body engages in large amounts of exercise, especially when the intensity increases suddenly or does not adapt to exercise, and is a special type of exercise muscle fatigue. [1] DOMs generally occur within 24H after exercise, and are eliminated automatically after reaching a peak of 24~72H by 5~7D. The main feature of DOMS is the production of DOMS after mechanical stimulation exercise training, its production mechanism and prevention methods have become one of the hot spots in the field of sports human science, and it is also a practical problem to be solved to limit the improvement of athletes'sports ability. Objective. What is the current situation of previous international research on the mechanism of delayed muscle soreness? What are the hotspots and trends of research? These are worth exploring.

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2.Data Sources

In order to carry out further exploration, the subject words of "Delayed muscle soreness" were searched in Web of Science database, the time span was 2009-2019, unlimited languages, countries and regions, a total of 707 related literatures were searched in the past ten years, and the title information of the documents was downloaded and saved in plain text format. Then these literatures were introduced into Cite Space5.5.R2 for knowledge graph drawing, and the research progress and dynamics of delayed muscle soreness were analyzed.

3.Results and Analysis

3.1 Distribution

3.1.1 Regional and Institutional Distribution

From the national distribution of 707 references, it can be seen that the first is the United States, with a total of the relevant text. Of the 186, followed by Australia,118, followed by the United Kingdom and Brazil,75 and 71, respectively. As a result, it can be seen that in the field of this study, the European and American countries are very active, and from the institutional distribution, the main research institutions are in institutions of higher learning, in which the University of Edisco is the first in 41 papers, followed by 22 from the University of Orburg, The second is that the University of Sao Paulo and the University of Jiayi, in a third and a third, have relatively little research on delayed muscle soreness in the country, which It is closely related to the local economic situation and the level of medical development, and it can be seen from time that the time of the document is concentrated in 2009, indicating the year of hot spot study for delayed muscle soreness in 2009.

Table 1 Main research institutions in the field of delayed muscle soreness. (top 8 in number of issues).

Crder number	Name of institution	Number of messages sent	Time	Centrality	Country
1	Edith Cowan Univ	41	2009	0.11	Australia
2	Aalborg Univ	22	2012	0.04	Denmark
3	Univ Sao Paulo	17	2009	0.08	Baxi
4	Natl Chiayi Univ	17	2009	0.00	Taiwan, China
5	Nagoya Univ	15	2009	0.06	Japan

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6	Univ Florida	14	2009	0.00	America
7	Univ Thessaly	13	2010	0.00	Greece
8	Univ Aalborg	11	2009	0.01	Denmark

3.1.2 Journal Distribution

Drawing delayed muscle soreness and high-cited journals can learn the authority of the main journal in this field. It can be seen from FIG.1 that the journal of the leading five is Med Sci Sport Exer (557 times), Eur J Appl Physiol (473 times), Sports Med (470 times), J Appl Physiol (440 times), J Strength Cond Res (385), as can be seen from the journal dependent countries, is still the case of the European and American countries The research attention is relatively high in the front of the field.

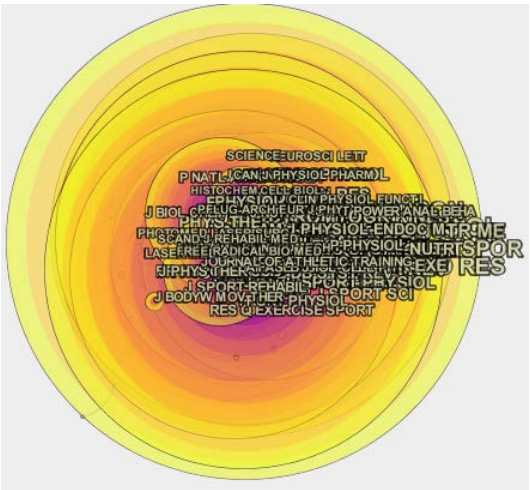

Fig. 1 Major cited journals in the field of delayed muscle soreness.

3.1.3 Distribution of Authors

Through the analysis of the high output authors in the field of delayed muscle soreness, we can find out the authoritative figures and their influence in this field, among which Kazunori Nosaka ranked first, Hsinlian Chen 14 times with 13, Trevor C Chen with 38 times, and their contribution degree can be seen.

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3.2 Research Hot Spots

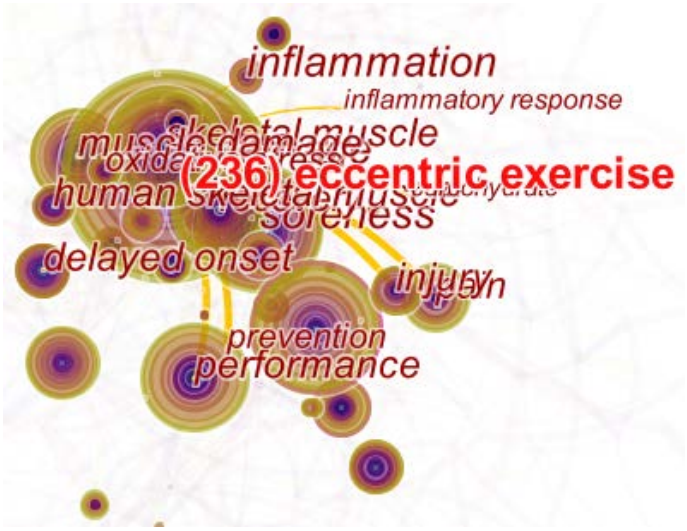

Fig. 2 Visualization map of key words in the field of delayed muscle soreness.

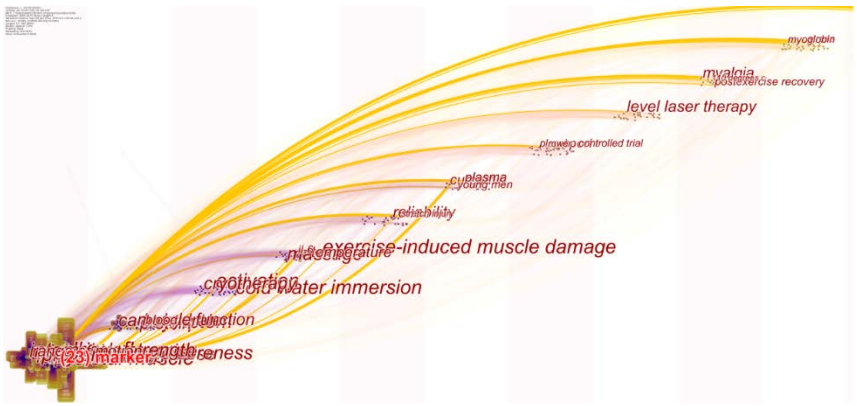

Figure 3 Delayed muscle soreness domain keyword 2009 / 2019 time zone view.

Table 2. High-frequency and high-school cardiac key words in the field of delayed muscle soreness.

Order number	High-frequency key word	Frequency	High centrality keyword	Central value
1	Eccentric exercise	236	Skeletal muscle	0.09
2	Exercise	158	Elbow flexor	0.09
3	Damage	150	Damage	0.07

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4	Skeletal muscle	148	Inflammation	0.07
5	Soreness	147	Intensity	0.06
6	Performance	132	Strength	0.06
7	Recovery	125	Muscle soreness	0.06
8	Muscle damage	113	Cold water immersion	0.05
9	Pain	96	Exercise	0.05
10	Creatine kinase	94	Delayed onset muscle soreness	0.05
11	Delayed onset musle soreness	83	Fatigue	0.05
12	Injury	80	Response	0.05
13	Fatigue	79	Dom	0.05
14	Delayed onset	78	Onset muscle soreness	0.05
15	Adaptation	74	Reperted bout	0.05

The key words focus on eccentric exercise, muscle injury and the mechanism of pain, fatigue mechanism of skeletal muscle, muscle motor intensity and so on. Most of the main research objects are the study of elbow flexion muscle, and the research on relief methods is mainly cold water immersion, which is usually closely related to the study of skeletal muscle inflammation. Through the processing of the time view of the hot keywords, we can draw figure 3, and analyze the corresponding changes in the research hotspots in the field of delayed muscle soreness in the decade of 2009 / 2019. the hot research period is 2009. During this period, the research mainly focuses on the muscle injury and the mechanism of pain. In recent years, the heat degree of the study has gradually decreased, and the research direction has changed to the recovery and response to muscle, the supplement of nutrients and the effect of hormones. Most of the subjects are women and adolescents. The source of the data includes questionnaire survey and clinical trial guidance, and most of the research adopts the method of Mate analysis.

3.3 Research Developments

3.3.1 Research Frontiers

In FIG.4, the research contents of the research field of delayed muscle soreness research show that the research content of the hot spot research group is mainly the motor-induced muscle injury, the low-intensity eccentric motion, the skeletal muscle performance, and the delayed muscle soreness. The focus of this year's study is to explore the prevention of a strain of a muscle strain, including compression, foam, and the like to prevent muscle strain. It can be seen that in the study of delayed muscle soreness, the focus of the study is to study the related mechanism of muscle soreness to the prevention of delayed muscle soreness. The number of the cited references will be analyzed and ranked by the lead 10 of the cited frequency to Table 3. As shown in the top 10, the first place is the articles published on SPORTS

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MED and EXERC IMMUNOL by Howatson G and Paulsen G, which have been cited 39 times.

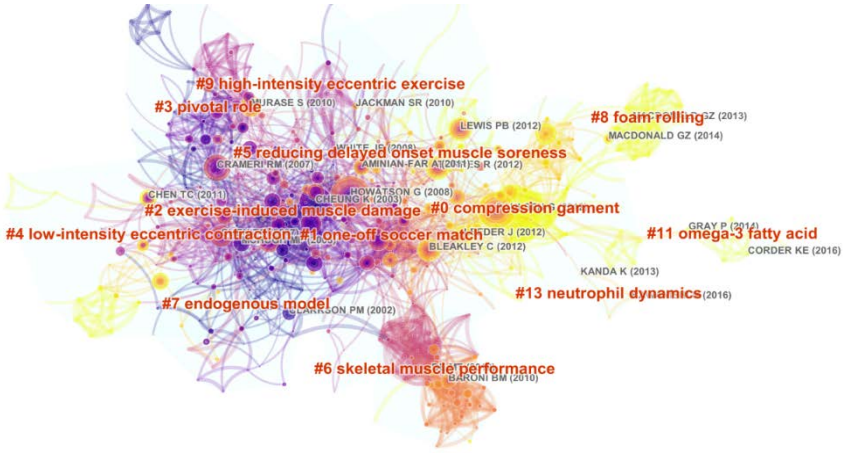

Fig. 4. Co-citation network map of the research literature in the field of delayed muscle soreness.

Table 3. High co-cited literature in the field of delayed muscle soreness (10 in the leading frequency).

Order number	Author,Title of literature,Time of publication, Source publication	Frequency
1	Paulsen G.Leucocytes,cytokines and satellite cells:What role do they play in muscle damage and regeneration following eccentric exercise?2012.EXERC IMMUNOL REV.	39
2	Howatson G.The prevention and treatment of exercise-induced muscle damage.2008.SPORTS MED.	39
3	Cheung K.Delayed onset muscle soreness - Treatment strategies and andperformance factors.2003.SPORTS MED.	32
4	Crameri RM.Myofibre damage in human skeletal muscle: effects of electrical stimulation versus voluntary contraction.2007.J PHYSIOL-LONDON.	29
5	Torres R.Evidence of the physiotherapeutic interventions used currently after exercise-induced muscle damage: Systematic review and meta-analysis.2012.PHYS THER SPORT.	25
6	Lewis PB.Muscle Soreness and Delayed-Onset Muscle Soreness.2012.CLIN SPORT MED.	25
7	Murase S.Bradykinin and Nerve Growth Factor Play Pivotal Roles in Muscular Mechanical Hyperalgesia after Exercise (Delayed-Onset Muscle Soreness.2010.J NEUROSCI.	23

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8	Chen TC.Intensity of eccentric exercise, shift of optimum angle, and the magnitude of repeated-bout effect.2007.J APPL PHYSIOL.	23
9	Bleakley C.Cold-water immersion (cryotherapy) for preventing and treating muscle soreness after exercise.2012.COCHRANE DB SYST REV.	23
10	Leeder J.Cold water immersion and recovery from strenuous exercise: a meta-analysis.2012.BRIT J SPORT MED.	22

3.3.2 Research Trends

The early study of delayed muscle soreness mainly focused on the pathogenesis of delayed muscle soreness. Six hypothetical theories were put forward, namely, lactic acid, muscle spasm, connective tissue injury, muscle injury, inflammation and enzyme efflux theory to explain delayed muscle soreness. Eccentric activity induced microinjury was more frequent and more serious than other types of muscle movements. Exercise intensity and duration are also important factors in the pathogenesis of DOMS. [2] based on the study of the mechanism, the intervention and preventive effects of exercise-induced muscle injury (Eimd) may be caused by new or unaccustomed exercise. Resulting in a temporary decrease in muscle strength, an increase in passive tension, and an increase in actin in the blood. [3] the most commonly used strategies to slow delayed muscle soreness include nutritional and pharmacological strategies, electrical and manual treatment and exercise. After that, scholars compared the related experiments on the basis of mechanism research, no longer to study the single pathogenesis, but to take delayed muscle soreness as the result of a variety of mechanisms. In order to prevent or minimize delayed muscle soreness and fatigue after exercise, many strategies are being used. In the treatment method, it tends to study the cold water immersion, cold water immersion, the water temperature is lower than 15 ℃. One of the most popular intervention strategies was used after exercise. Compared with passive intervention, including rest or no intervention, cold water immersion reduced muscle soreness after exercise. [4]

4.Conclusion

Delayed muscle soreness is studied in high-output countries and institutions. The authors are mainly concentrated in Europe, the United States and Australia. The hot spots in the field of research mainly include eccentric exercise, skeletal muscle, muscle injury, cold water immersion, inflammation and so on. From the point of view of research content, the research focus of delayed muscle soreness is from mechanism to treatment. The focus of future research may be the prevention strategy of delayed muscle soreness and the influence of other interference factors on the formation of research muscle soreness and the rational use of the strategy.

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[2] K Cheung.(2003) Delayed onset muscle soreness - Treatment strategies and andperformance factors.SPORTS MED. vol. 33, pp.145.

[3] G Howatson.(2008) The prevention and treatment of exercise-induced muscle damage.SPORTS MED.. vol. 38, pp.483.

[4] C Bleakley.(2012) Cold-water immersion (cryotherapy) for preventing and treating muscle soreness after exercise.COCHRANE DB SYST REV. vol.13, no.5, pp.12-19.