Resveratrol and exercise: a review on the effects of resveratrol on physical and sport performance

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ABSTRACT. Phenolic compounds have been shown to be important molecules in human metabolism. Among these, resveratrol, found primarily in the skin of red grapes, has been touted as a promising adjuvant in the treatment and prevention of disease. Recently, the ergogenic potential of resveratrol has been investigated, however, showing diverging results. The purpose of this review was to analyze and discuss studies that evaluated the effects of resveratrol supplementation on exercise performance. The search terms resveratrol, physical exercise and exercise training on the PubMed platform were used, resulting in 18 studies eligible for the selection criteria. The selected studies confirm that there is no consensus in the scientific literature about the ergogenic potential of resveratrol. The selected studies do not point to a common result, and even similar experimental interventions show divergent results.

Keywords: Aerobic exercise, Exercise, Resveratrol, Supplementation.

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INTRODUCTION

The search for a healthy diet is linked to the search for foods that, besides their nutritional value, play a potentially beneficial role in reducing the risk of chronic diseases. One of these foods is grapes, the raw material for juices and wines. Moderate consumption of red wine and grape juice may have protective effects, reducing the risk of developing cardiovascular disease, atherosclerosis, hypertension, certain types of cancer, type 2 diabetes, neurological disorders, and metabolic syndrome (Golan, Gepner, & Shai, 2019). The beneficial effects of consuming grape derivatives are related to the phenolic compounds found in the fruit, especially resveratrol (RESV). Because of its ability to neutralize free radicals, reducing/preventing oxidative stress, and because of its anti-inflammatory potential, resveratrol has been widely studied (Guerrero, García-Parrilla, Puertas, & Cantos-Villar, 2009).

In a literature review, Hecker et al. (2022) set out to study the effects of RESV on skin aging. The authors inferred that this phenolic compound shows promise in protecting the skin against photoaging as a result of its antioxidant and anti-inflammatory potential. In addition, by stimulating the synthesis of elastin and collagen by fibroblasts, RESV also helps to promote skin elasticity and firmness, increase hydration, and reduce wrinkles.

In their study, Vatavuk-Serrati et al. (2019) discuss the action of RESV on cardiovascular disease, cancer, neurodegenerative diseases, diabetes, hyperglycemia, as well as its possible effects on longevity. The authors suggest that RESV supplementation is safe and beneficial, acting positively on endothelial function, the glycemic profile of patients with insulin resistance, and inflammation.

There is consensus in the literature about the positive effects of RESV on health parameters. However, recent studies suggest that this phenolic compound also has an ergogenic effect in individuals undergoing exercise training. Some research, both in humans and animals, has indicated positive effects of resveratrol supplementation on sports performance (Alway et al., 2017; Hart et al., 2014). On the other hand, other experiments with humans have shown that RESV does not affect or negatively affects performance in different physical valences (Olesen et al., 2014; Scribbans et al., 2014, Tsao et al., 2021). Thus, despite the growing number of studies, the findings on the subject remain scarce and discrepant.

As an antioxidant compound, RESV can aid recovery after exertion and reduce the wear and tear caused by exercise sessions, contributing to the adaptive process to training and improving physical performance. In addition, RESV supplementation can improve mitochondrial activity, enhancing mouse

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bioenergetic capacity and substrate utilization, and consequently improving performance in a stress test. Thus, the purpose of this literature review was to analyze and discuss data from studies evaluating the effects of resveratrol supplementation on exercise performance.

MATERIALS AND METHODS

This literature review was based on the PRISMA (EQUATOR) protocol recommended for review studies. The searches were performed exclusively in the Medline PUBMED database. The strategies for searching this database involved selecting the descriptors (MeSH Terms) resveratrol, physical exercise, exercise training, in a combined way through the boolean operator “and” (resveratrol “and” physical exercise / resveratrol “and” exercise training).

Studies that addressed the topic “resveratrol supplementation and physical performance” were eligible, and only those published after 2010 and in English were included. Review studies, meta-analysis, commentaries, letter to the editor, and brief communications were excluded. Studies conducted with specific groups, such as individuals with declared diseases (cancer, heart disease, diabetes, obesity, and motor difficulties) and animals subjected or induced to special health/disease conditions, such as diabetes, hypertension, and obesity, were also excluded.

Other criteria used for selection of the manuscripts are that they specifically address the subject in question as the main theme of the study, that there is no association of the ESRB with another food supplement or drug, quality of experimental design and sampling, methodological rigor, and consistency of conclusion (subjective parameters evaluated by the authors).

First, repeated or duplicate published studies were excluded. Then the titles of the papers were evaluated according to the exclusion and inclusion criteria. The abstracts of the remaining studies were read in their entirety and filtered according to the established criteria and their relation to the object of study of the present review. Finally, the full texts were assembled for evaluation according to the criteria described above.

RESULTS

The initial search resulted in 399 scientific articles. Sixty-three duplicate or repeated studies were excluded, and the remaining filters eliminated 318 articles. Thus, only 18 studies were considered eligible according to the standards set for this literature review (Figure 1).

Ten of the selected studies evaluated the proposed intervention in animal models, mainly mice. Eleven studies have evaluated the effects of supplementation and training in animals or untrained individuals. Only two studies did not include training in their experimental intervention, and among the studies that did include training, cardiorespiratory endurance training predominated. Eight studies found the RESV to have some ergogenic and/or adjunctive effect to applied physical training, while five studies observed no effect on the variables tested. Blocking and inhibitory effects of RESV supplementation to the adaptations promoted by applied training were evidenced in five studies (Table 1).
Table 1: Studies on the effects of resveratrol on exercise performance.

<table>
<thead>
<tr>
<th>Authors</th>
<th>Experimental model</th>
<th>n</th>
<th>Pre-intervention training level</th>
<th>Type of exercise</th>
<th>Training time</th>
<th>Dose of RESV</th>
<th>Supplementation Time</th>
<th>Effect on performance</th>
<th>Other effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Kan et al., 2018)</td>
<td>Mice</td>
<td>40</td>
<td>Untrained</td>
<td>Strength</td>
<td>4 weeks</td>
<td>25 mg/kg/day</td>
<td>4 weeks</td>
<td>Increased strength, climbing speed and aerobic endurance. Anti-fatigue effect.</td>
<td>Increased cross-sectional area of skeletal muscle.</td>
</tr>
<tr>
<td>(Muhammad &amp; Allam, 2018)</td>
<td>Older mice</td>
<td>30</td>
<td>Untrained</td>
<td>Aerobic endurance</td>
<td>4 weeks</td>
<td>15 mg/kg/day</td>
<td>4 weeks</td>
<td>Anti-fatigue effect.</td>
<td></td>
</tr>
<tr>
<td>(Olesen et al., 2014)</td>
<td>Older men</td>
<td>43</td>
<td>Untrained</td>
<td>High Intensity Interval Training</td>
<td>8 weeks</td>
<td>250 mg/day</td>
<td>8 weeks</td>
<td>No effect on aerobic endurance.</td>
<td></td>
</tr>
<tr>
<td>(Ringholm et al., 2013)</td>
<td>Mice</td>
<td>30</td>
<td>Untrained</td>
<td>Aerobic endurance (ad libitum)</td>
<td>48 weeks</td>
<td>4 g/kg feed</td>
<td>48 weeks</td>
<td>No effect on aerobic endurance.</td>
<td>Resveratrol did not affect the expression of oxidative proteins in skeletal muscle.</td>
</tr>
<tr>
<td>(Huang et al., 2021)</td>
<td>Young men</td>
<td>36</td>
<td>Active</td>
<td>-</td>
<td>-</td>
<td>500 mg/day and 1000 mg/day</td>
<td>1 week</td>
<td>Small increase in maximal strength in anaerobic effort.</td>
<td>Reduction of muscle damage caused by exercise.</td>
</tr>
<tr>
<td>(Dolinsky et al., 2012)</td>
<td>Older mice</td>
<td>50</td>
<td>Untrained</td>
<td>Aerobic endurance (treadmill)</td>
<td>12 weeks</td>
<td>4 g/kg feed</td>
<td>12 weeks</td>
<td>Increased aerobic capacity and strength.</td>
<td>Improvement of fatty acid metabolism. Reduced insulin resistance and improved cardiac function.</td>
</tr>
<tr>
<td>(Alway et al., 2017)</td>
<td>Older men and women</td>
<td>30</td>
<td>Untrained</td>
<td>Aerobic endurance and strength exercise</td>
<td>12 weeks</td>
<td>500 mg/day</td>
<td>12 weeks</td>
<td>Increased aerobic capacity and type I muscle fiber hypertrophy.</td>
<td></td>
</tr>
<tr>
<td>(Gliemann et al., 2013)</td>
<td>Older men</td>
<td>37</td>
<td>-</td>
<td>Aerobic endurance and strength exercise</td>
<td>8 weeks</td>
<td>250 mg/day</td>
<td>8 weeks</td>
<td>Blocking the increase in maximal oxygen consumption and no effect on functional capacity.</td>
<td>Resveratrol reduced positive effects of training on lipid profile.</td>
</tr>
<tr>
<td>(Scribbans et al., 2014)</td>
<td>Young adult humans</td>
<td>16</td>
<td>Active</td>
<td>High Intensity Interval Training</td>
<td>4 weeks</td>
<td>150 mg/day</td>
<td>4 weeks</td>
<td>Blocking the increase in maximal oxygen consumption and maximal anaerobic power.</td>
<td></td>
</tr>
<tr>
<td>(Hart et al., 2013)</td>
<td>Adult mice (high running capacity)</td>
<td>24</td>
<td>Untrained</td>
<td>Aerobic endurance</td>
<td>12 weeks</td>
<td>150 mg/kg/day</td>
<td>16 weeks</td>
<td>Increased aerobic endurance and hind limb strength.</td>
<td>Resveratrol increased the relative amount of mitochondrial DNA in skeletal muscle.</td>
</tr>
</tbody>
</table>
| (Hart et al., 2014)      | Adult mice (low running capacity) | 24 | Untrained                       | Aerobic endurance                 | 12 weeks      | 150 mg/kg/day | 16 weeks | Blocking the increase in aerobic | }
<table>
<thead>
<tr>
<th>Study (Year)</th>
<th>Species</th>
<th>Age/Activity</th>
<th>Treatment</th>
<th>Duration</th>
<th>Dose</th>
<th>Duration</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kan et al. (2016)</td>
<td>Adult mice</td>
<td>50 Untrained</td>
<td>Aerobic endurance</td>
<td>4 weeks</td>
<td>25 mg/kg/day</td>
<td>4 weeks</td>
<td>Increase in hind limb strength. No effect on aerobic endurance.</td>
</tr>
<tr>
<td>Xiao (2015)</td>
<td>Adult mice</td>
<td>- Untrained</td>
<td>Aerobic endurance</td>
<td>4 weeks</td>
<td>25, 50 or 100 mg/kg/day</td>
<td>4 weeks</td>
<td>Increase in aerobic endurance. No antioxidant effect compared to isolated training.</td>
</tr>
<tr>
<td>Tsao et al. (2021)</td>
<td>Young men</td>
<td>8 Physically active</td>
<td>-</td>
<td>-</td>
<td>480 mg/day</td>
<td>4 days</td>
<td>No effect on aerobic endurance.</td>
</tr>
<tr>
<td>Rodriguez-Bies, Tung, Navas, &amp; López-Lluch (2016)</td>
<td>Young, adult and old mice</td>
<td>54 Untrained</td>
<td>Aerobic endurance</td>
<td>18 weeks</td>
<td>16-17 mg/kg/day</td>
<td>18 weeks</td>
<td>Increased aerobic endurance in adults and the elderly, and increased hind limb strength in the elderly. Resveratrol reduced markers of oxidative damage.</td>
</tr>
<tr>
<td>Voduc, LaPorte, Tessier, Mallick, &amp; Cameron (2014)</td>
<td>Adult humans</td>
<td>12 Untrained</td>
<td>-</td>
<td>-</td>
<td>1000 mg/day</td>
<td>4 weeks</td>
<td>No effect on endurance and aerobic capacity.</td>
</tr>
<tr>
<td>Ryan et al. (2010)</td>
<td>Young and old mice</td>
<td>53 Untrained</td>
<td>-</td>
<td>-</td>
<td>5g/kg feed</td>
<td>10 days</td>
<td>No effect on former fatigue and isometric muscle contraction strength. Resveratrol reduced oxidative stress in exercised muscle.</td>
</tr>
</tbody>
</table>
DISCUSSION

The results of the literature survey performed in the present study confirm the lack of a consensus in the scientific literature about the ergogenic potential of RESV supplementation. The selected studies do not point to common results, and even similar experimental interventions show discrepant or inconclusive results. Thus, the need to discuss and deepen the observation of the mechanisms that relate the RESV to the improvement of sports performance is reinforced.

Of the 18 articles selected in the present review, five did not observe any effect of the RESV on the physical valence tested (Olesen et al., 2014, Ringholm et al., 2013, Ryan et al., 2010, Tsao et al., 2021, Voduc et al., 2014). Of these, four evaluated aerobic endurance, which is the physical valence indicated as the main beneficiary of RESV supplementation.

The studies that applied the experimental protocols in humans and observed no ergogenic effect offered different doses of the supplement (250, 480 and 1000 mg/day) (Olesen et al., 2014, Tsao et al., 2021, Voduc et al., 2014). This suggests that the lack of effect may not be related to the amount of supplement ingested. However, the period under supplementation was different, ranging from 4 days to 8 weeks.

In evaluating the RESV intake of mice undergoing training for 48 weeks, Ringholm et al. (2013) found no significant effect of supplementation on the aerobic endurance of the animals tested. The biomolecular findings did not point to any interference of RESV on the expression of enzymes of oxidative metabolism (Ringholm et al., 2013). These data suggest that RESV supplementation, even if daily, over a lifetime, is not sufficient to improve performance in endurance effort.

While some papers suggest that RESV supplementation is not effective in improving endurance performance, seven of the selected studies showed favorable results for supplementation with the phytochemical (Alway et al., 2017, Dolinsky et al., 2012, Hart et al., 2013, Kan et al., 2018, Muhammad & Allam, 2018, Rodriguez-Bies et al., 2016, Xiao, 2015), where only one of these evaluated the effects of supplementation in humans (Alway et al., 2017). According to the study by Alway et al. (2017), daily intake of 500 mg of RESV enhances the effect of concurrent training (endurance and strength) on aerobic endurance in elderly subjects of both sexes. Furthermore, the study pointed to an association between supplementation and hypertrophy of type I muscle fibers, the muscle fibers specialized in aerobic metabolism.

Animal model studies have also verified the positive effect of RESV on aerobic endurance in elderly guinea pigs (Rodriguez-Bies et al., 2016, Muhammad and Allam (2018), and Dolinsky et al., 2012). According to the authors, the effects of RESV are related to a reduction of oxidative stress in the muscle of the supplemented animals. Since elderly individuals have impaired antioxidant function, RESV contributes to the enhancement of defenses against oxidative damage caused by reactive species. Ryan et al. (2010) also found an antioxidant effect of the RESV in exercised muscle of aged animals, but did not identify any ergogenic effect of the supplement.

Kan et al. (2018) obtained a positive result of RESV supplementation with potentiation of the effects of strength training in adult mice. After 4 weeks of stair climbing training, the supplemented mice showed improved strength, speed, and resistance to fatigue compared to the unsupplemented mice. The authors also showed that the RESV is able to contribute to the increase in the cross-sectional area of the muscle, agreeing with the findings of Alway et al. (2017). Other studies have also shown increased strength in response to RESV supplementation, even without the insertion of strength training during the experiment (Dolinsky et al., 2012, Hart et al., 2013, Huang et al., 2021, Kan et al., 2016, 2018, Rodriguez-Bies et al., 2016).

Three studies have shown a negative effect of RESV supplementation, two of them in humans (Gliemann et al., 2013, Hart et al., 2014, Scribbans et al., 2014). These studies point out that supplementation blocks or inhibits the positive effects of training on aerobic capacity and potency. One of these studies found that supplementation reduces strength gains (Hart et al., 2014), while another manuscript points out that RESV even impairs the effects of training on the lipid profile in the elderly (Gliemann et al., 2013). The negative effects of antioxidant supplementation on training adaptations are known in the literature. Gomez-Cabrera et al. (2008) have shown that antioxidant vitamin supplementation blocks the transcription of genes related to the enhancement of aerobic metabolism, impairing performance in both humans and animals.

Two studies by the same group of authors showed absolutely opposite results (Hart et al., 2014, 2013). One of the studies showed that RESV supplementation is positive for endurance performance in animals with high running ability (Hart et al., 2013). However, the second study highlights that RESV impairs training adaptation in animals with low running ability (Hart et al., 2014). While resveratrol collaborated in increasing mitochondrial DNA in the running animals, the opposite was observed in the animals of limited running ability. In their discussion, the authors suggest that the response to RESV appears to be selective with respect to the metabolic characteristics of individuals.

Although the ergogenic effects of RESV are discussed and publicized, the selected studies do not
show favorable results for supplementation with this phytochemical in humans. Only two studies have shown positive effects in humans, while six studies point to no effect or a negative effect. It should be considered that the studies used different dosages of RESV, with varying protocol duration, and different training programs. These variations expand the possibilities for supplementation and training protocols, yet few favorable results have been noted.

In order to make the data more robust, this literature review listed only studies published in English language journals and indexed in the Medline PUBMED database. However, this search pattern limited the number of studies found, and did not cover quality studies published in other languages. Furthermore, the present study did not consider/evaluate the level of evidence of the eligible papers. Thus, a systematic review on the effects of resveratrol supplementation on sports performance, which considers the level of evidence of the studies as well as the experimental model applied, is needed.

**FINAL CONSIDERATIONS**

The findings of the present review suggest that RESV supplementation has not established itself as an ergogenic resource. However, this cannot be completely ruled out, as several studies have found some positive effect of supplementation on physical performance. It can be defined that the effects of ingesting RESV do not equate to exercise training, nor does it replace it. Thus, the hypotheses must be based on the adjuvant effect of physical training.

The small number of studies selected reveals the need for more experimental trials on the topic, especially clinical trials, since few manuscripts have been dedicated to studying the effects of RESV on physical performance in humans. There is still a need for studies in the scientific literature that investigate these effects under various conditions, considering dosage, protocol duration, and type of exercise. Therefore, the present study points to the lack of consensus in the literature about the ergogenic effect of RESV supplementation and the need for clinical studies on the subject.

**DECLARATION OF CONFLICT OF INTEREST**

The author(s) have not declared any potential conflict of interest regarding the research, authorship and/or publication of this article.

**REFERENCES**


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