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Original Investigation

Boosting Strength and Awareness: Effects of Resistance Training on Adolescents' Perceptions and Progress. A Pilot study

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Purpose: The aim of the study is to explore the connection between the impact of the physical effects of a training protocol for the development of resistance strength on adolescents' perceptions, opinions and awareness.
Methods: A sample of 12 subjects aged 10-12 years, all male, took part in the present study. The procedure is the administration of the Broad Jump Test before and after the strength versus endurance development training protocol, with subsequent administration of a questionnaire consisting of 2 items: the first on perceptions and opinions, the second on awareness. To analyse the data, the student's t-test for dependent samples, descriptive statistics, the Chi Square Test (X2) and Pearson's correlation were used.
Results: 9.86% increase in strength was observed (P= .0016). Regarding perceptions, 66.7% of participants felt more energized after the training, correlating with greater awareness of their abilities and progress (P= .028). Additionally, 83.3% found the protocol stimulating, linked to improved recognition of bodily responses (P= .020). Among those who felt fit (91.7%), a deeper understanding of body responses emerged (P< .001). Lastly, 83.3% who noted increased energy showed heightened sensitivity to action outcomes (P= .028).
Conclusions: The results suggest a close connection between strength development and the positive impact on individual perceptions and awareness, indicating that resistance training protocols not only promote physical adaptations, but also foster awareness of the connections between improvement and benefit.

Keywords: strength; developmental age; Broad Jump Test; specific training; questionnaire.

Introduction

Developmental strength training is a debated topic, including that against resistance.[1] The neuromuscular system produces force through processes in which different integrated structures are activated with the right timing and sequence.[2] Moreover, muscle strength is not only a key physical component of sports performance, but also plays a crucial role in overall health, contributing to improved bone density, functional capacity, and prevention of chronic noncommunicable diseases.[3] The phenomenon that marks the transition from childhood to adulthood involves several stages that are intertwined and progress simultaneously: growth, maturation, and development.[4] Growth consists of increasing body measurements, maturation refers to progressing to greater levels of structural maturation, and development concerns the acquisition of behavioral skills.[5,6] This complex intertwining of growth, maturation, and development makes it particularly important to adopt specific training protocols, tailored to individual needs and abilities, to promote harmonious development both physically and psychologically.[7,8]
In the past, there was a belief that counter-resistance training was inappropriate and unsuitable for young people.[9] In 1983 the American Academy of Pediatrics published an investigation in which a group of teenage powerlifters who entered the "Michigan Teenage Powerlifting Championship" were examined, who during the study reported a high number of injuries particularly in the area near the last lumbar vertebrae and sacrum.[10] Over the years, however, because of numerous research and investigations on the subject, it emerged that, counter-resistance training can have a positive impact on the developmental and growth processes of young.[11] In accordance with this, the World Health Organization (WHO) has included in its physical activity guidelines that individuals during developmental age should have, at least 3 times a week, activities for muscle strengthening.[12] This recommendation emphasizes the value of strength training also as an educational and preventive tool, aimed at countering phenomena such as sedentariness and childhood overweight, which are growing risk factors in the youth population.[13,14]
According to the Russian methodologist Filin, until about age 12, the load lifted should be proportionate to the young athlete's body weight; this is referred to as relative strength. As for absolute strength, however, it should be trained only when there is an increase in testosterone production, its release and peripheral sensitization to it. In parallel, it is crucial to consider the psychosocial and cultural context in which strength training is developed: educating young people to perceive this practice as a safe, motivating, and integrated activity in a comprehensive approach to wellness is a priority goal.[15,16] The National Strength and Conditioning Association suggests that among the benefits of resistance training, you can find the refinement of skills and the attainment of better psychosocial status.[17] In fact, one of the advantages of strength training is the high degree of success, resulting in the ability to be completed without too much difficulty even by kids with weight or other issues.[18] This makes strength training an inclusive opportunity that can adapt to the

needs of young people with different skill levels and physical conditions, promoting not only performance but also self-esteem and socialization.[19]

The issue that this study highlights is that in the scientific literature, there is a lack of data on the influence that counter-resistance training protocols can have on young people's psychophysical development, in terms of improving muscle strength and awareness of perceived benefits. Previous studies have shown that intrinsic motivation, fostered by activities perceived as challenging and engaging, can improve both long-term participation and achievement. Considering the perceptual aspect and awareness of young people allows for a broader understanding of the effects of resistance training, going beyond mere performance results and investigating the educational and training value of such practice. Assessing the perceived values, opinions, and knowledge of athletes can provide crucial data to optimize training protocols.[20] This approach makes it possible to analyse not only performance improvements, but also psychological and motivational aspects that may affect participation and continuity of training. Strength training is a debated topic in the developmental age group, including that against resistance. There is often the difficulty of commensurate the appropriate workload with the effects it produces due to the variability of physiological and psychophysical adaptations; these may even differ among athletes even of the same age group. Such differences do not allow for the optimization of various parameters and criteria in training methods because it neglects the person who has his own perceptions, opinions and knowledge. In specific scientific literature, there is a lack of evidence on the connections that may exist between improvements in strength versus endurance, after the administration of a training protocol, and athletes' perceived values, related opinions and new learnings for possible use in personalized collective exercise education.

The aim of the study is to explore the connection between the impact of the physical effects of a training protocol for the development of resistance strength on adolescents' perceptions, opinions and awareness. In particular, the study aims to investigate how increasing strength levels may influence young people's self-perception and their degree of awareness of the psychophysical effects achieved through exercise.

Methods

Study Participants

The sample consisted of 12 male subjects, recruited by convenience sampling. The age of the participants ranged from 10 to 12 years, with a mean age of 11.2 years (± 0.8). The mean height of the participants was 145.3 cm (± 5.2) and the mean body mass was 37.8 kg (± 4.6). The sample's physical activity level was moderately active. Furthermore, the participants had no previous experience with resistance training. Inclusion criteria included being male, aged between 10 and 12 years, moderately active and without previous resistance training experience. Exclusion criteria were the presence of any medical condition that might prevent safe participation in physical activity or resistance training. No training experience was required for this study.

Study Design

This study adopts a pilot pre-post intervention design to evaluate the effects of a resistance training protocol on strength performance and awareness in adolescents aged 10-12 years. Given the exploratory nature of this pilot study, a single group of participants was assessed before and after the intervention to determine initial feasibility, effectiveness, and perceptual outcomes of the proposed training protocol. T Broad Jump Test was carried out, which allowed us to understand the initial strength levels of the young athletes, depending on the distance reached. The test consists of performing a broad jump, starting from a standing position, trying to jump as far as possible. To standardise the test, the athletes were all made to start from the same position, delineated with a white line. After the jump, the athletes were asked to stand still at the point where they had arrived, and with a millimetre wheel, the distance from the take-off position to the end position was taken, considering the heel support point. Scoring was based on the maximum distance achieved, expressed in centimetres (cm), considering the best result of two attempts. The Broad Jump Test served as the primary outcome measure to assess lower limb explosive strength before and after the intervention, providing a quantitative benchmark for evaluating the effects of the training protocol.

A strength training protocol was then developed, administered once a week, entirely for one sport season, that is, from September to June, for the duration of 10 months. The training took place in a sports facility, consisting of a football pitch and a gymnasium. The designated training protocol includes an initial technical warm-up phase, which engaged the athletes for 15 minutes. Immediately afterwards, a Small Side Game was proposed, i.e. a game on a reduced pitch with the theme of using four small goals. Each goal is indicated with a different coloured chine. The athletes, in the first phase of the game, have the objective of maintaining possession of the ball until the voice command of the coach, who will signal a colour: the latter will indicate the goal to which the teams must carry the ball Afterwards, the athletes divided into 3 stations, performing a technical-coordinating task:

- First station: sprint towards the first cone, stop and subsequently sprint towards a second cone;
- Second station: monopodalic jump over the mat with landing in a circle and final sprint towards the cone;
- Third station: bipodalic jump over obstacles and sprint towards the cone.

Strength training in the gym is divided into several well-structured phases. The first phase, lasting 15 minutes, is dedicated to activation, during which participants perform exercises on treadmills, exercise bikes and ellipticals, all 3 machines of TechnoGym (Gambettola, Italy), to warm up the body. This part also includes joint mobility exercises and dynamic stretching using elastic bands and mats. After activation, we work on the correct postural execution of motor gestures. In this initial phase, subjects perform free-body exercises such as squats, push-ups, squats, planks and crunches, with between 8 and 12 repetitions, depending on individual ability. Recovery times between sets are 30-60 seconds, to ensure adequate muscle recovery without losing concentration. Once a good motor balance has been achieved, participants move on to overload exercises, using specific machines to work on targeted muscle groups. Among the machinery used are:

- Leg press e leg curl for the lower limbs;
- Lat machine e chest press for the back and chest muscles;
- Shoulder press and biceps curl machine for shoulders and arms.

The three machines mentioned, namely Leg Curl, Lat Machine and Shoulder Press are from the Life Fitness company. This structured protocol, combining motor learning exercises, technical-coordinative tasks, and progressive resistance training, was designed to promote strength adaptations while ensuring safety and engagement appropriate for developmental age.

The sessions, lasting approximately 90 minutes, were carefully monitored to minimize injury risk and maximize participant adherence.

The overload exercises follow structured protocols for increasing strength, with 3-4 sets of 6-8 repetitions and progressive overloads of 70-85% of the maximal (1RM) previously assessed with a Brzycki method. Recovery times between sets are 90-120 seconds, to facilitate the neuromuscular recovery required by strength-oriented training. The programme mainly involves the following muscle groups: for the lower limbs, quadriceps, ischiocrucials, calves and buttocks; for the upper limbs, biceps, triceps and deltoids; and the trunk muscles comprising pectorals, lats and core stabilising muscles (abdominals and lumbars). Subsequently, the Broad Jump Test was carried out again to understand the strength levels achieved by the young athletes, post-implementation of the training protocol. As this study is exploratory and conducted on a small sample, it serves as a pilot investigation to generate preliminary evidence on the impact of resistance training in developmental age. The findings aim to inform future studies with larger samples and more robust experimental designs, including the potential inclusion of a control group.

Questionnaire

It was created and administered to participants at the end of their training via Google forms and disseminated via social networks. The questionnaire contains 3 questions with 2 response items that can be answered with YES/NO. It focuses on the perception and opinions of the young participants.

Perception questionnaire:

1) Do you feel that this training programme makes you feel more energetic?
2) Do you feel motivated and/or enthusiastic about doing this training programme?
3) Having never done this training; do you feel fit to do it?

Subsequently, a mindfulness questionnaire was administered, where the impact of the strength-building training protocol in terms of awareness development was analysed. The latter was also administered via Google forms and disseminated via social networks. The questionnaire contains 3 questions with 2 response items that can be answered with YES/NO.

Awareness questionnaire:

1)Did the training protocol help you recognise your strengths and areas for improvement in a more conscious way?

2) Do you feel that using the protocol performed has made you more aware of how your body reacts to physical or mental effort?

3) Have you felt more aware of the impact of your actions (physical or mental) on others or your surroundings?

All subjects gave their informed consent for inclusion before participating in the study. The study was conducted in accordance with the Declaration of Helsinki. According to Regulation (EU) 536/2014 and Directive 2001/20/EC, research that poses minimal risks to participants may be exempt from formal ethical review as it does not involve invasive or experimental interventions. In addition, according to Legislative Decree No. 211 of 24 June 2003, research that does not present significant risks and is aimed exclusively at improving educational practices may be exempt from review and approval by the Institutional Review Board (IRB) or Ethics Committee.

Statistical Analysis

After checking the normality of the data with the central tendency indices: fashion, mean and median, and the representativeness of the mean with the standard deviation, a T-test was performed for independent samples to analyse the differences between the groups. Significance was set at $P < .05$. To test how much the training practice affected the participants' perception and subsequently awareness, the Chi Square (X^2) Test was applied to measure any significant relationships between the qualitative variables. Again, significance was set at $P < .05$. Furthermore, Pearson's correlation was used to assess the correlation between the quantitative variable, i.e. the increase in strength, with the qualitative variables, i.e. perception and awareness. The analysis was conducted using the Statistical Package for Social Science software (IBM SPSS Statistics for Windows, version 25.0, IBM, SPSS Inc., Armonk, NY, USA).

Results

Data Quality Check

The results collected at the beginning of the course showed an average distance of 113.5 cm, with a standard deviation of ± 6.16 cm.

Table 1. Broad Jump Test results in pre and post training.

Athlete	Broad Jump Test (cm)	
	Pre training	**Post training**
N1	115	124
N2	109	126
N3	106	132
N4	120	145
N5	121	145
N6	110	121
N7	106	111
N8	109	114
N9	120	122
N10	115	119
N11	110	113
N12	121	124

T-Test application

The results at the end of the course showed a clear improvement in jumping ability in all athletes. There was an average improvement of approximately 11.2 cm. The mean, in this case, increased to 124.7 cm, with a standard deviation of ± 11.17 cm. When comparing the strength results in the lower extremities pre- and post-intervention, a statistically significant result emerged (P=.002).

Results of questionnaires

Table 2 shows the results of the perception questionnaire.

Table 2. Analysis of Perception Questionnaire Responses

Variable	Options	Frequency
1P) Do you feel that this training programme makes you feel more energetic?	YES	8 (66.7%)
	NO	4 (33.3%)
2P) Do you feel motivated and/or enthusiastic about doing this training programme?	YES	10 (83.3%)
	NO	2 (16.7%)
3P) Having never done this training, do you feel fit to do it?	YES	11 (91.7%)
	NO	1 (8.3%)

With regard to the questionnaire on awareness, to question 1P 'Do you feel that this training programme makes you feel more energetic?' 66.7% answered YES and the remaining 33.7% NO. To question 2P 'Do you feel motivated and/or enthusiastic about doing this training programme?' 83.3% answered YES and the remaining 16.7% NO. Finally, to question 3P 'Having never done this training, do you feel fit to do it?' 91.7% answered YES and the remaining 8.3% NO. Next, the results of the awareness questionnaire are shown in Table 3.

Table 3. Analysis of Awareness Questionnaire Responses

Variable	Options	Frequency
1C) Did the training protocol help you recognise your strengths and areas for improvement in a more conscious way?	YES	10 (83.3%)
	NO	2 (16.7%)
2C) Do you feel that using the protocol performed has made you more aware of how your body reacts to physical or mental effort?	YES	11 (91.7%)
	NO	1 (8.3%)
3C) Have you felt more aware of the impact of your actions (physical or mental) on others or your surroundings?	YES	9 (75%)
	NO	3 (25%)

To the questionnaire on awareness 1C 'Did the training protocol help you recognise your strengths and areas for improvement in a more conscious way?' 83.3% answered YES, while the remaining 16.7% answered NO. Subsequently to the question 2C 'Do you feel that using the protocol performed has made you more aware of how your body reacts to physical or mental effort?' 91.7% answered YES and the remaining 8.3% NO. Finally, to the question 3C 'Have you felt more aware of the impact of your actions (physical or mental) on others or your surroundings?' 75% answered YES and the remaining 25% NO.

Comparison between quantitative and qualitative significance

After the analysis of the answers, the Chi-square test was applied, where several significant relationships were found. This can be observed in summary table number 4.

Table 4. Table summarising the performance gains with significance and the most significant correlations between the corresponding answers in the questionnaire.

				QUALI-QUANTITATIVE DATA	
QUANTITATIVE DATA			*P-value*		*P-value*
Broad Jump Test	Inc %	9.86%	.002	1P) Do you feel that this training programme makes you feel more energetic? 1C) Did the training protocol help you recognise your strengths and areas for improvement in a more conscious w**a**y?	.028
				2P) Do you feel motivated and/or enthusiastic about doing this training programme? 2C) Do you feel that using the protocol performed has made you more aware of how your body reacts to physical or mental effort?	.020
				3P) Having never done this training, do you feel fit to do it? 2C) Do you feel that using the protocol performed has made you more aware of how your body reacts to physical or mental effort**?**	<.001
				1P) Do you feel that this training programme makes you feel more energetic? 3C) Have you felt more aware of the impact of your actions (physical or mental) on others or your surroundings?	.028

In order to link the data from the Broad Jump Test with the data from the perception and awareness questionnaires, the performance increase of the Broad Jump Test (in cm) was calculated for each athlete and the average of the answers on both perception (calculated from the answers to 1P, 2P and 3P: YES=1, NO=0) and awareness (calculated from the answers to 1C, 2C and 3C: YES=1, NO=0). A detailed description is shown in Table 5.

Table 5. Increased performance and average levels of perception and awareness.

Athlete	Increase Test (cm)	Perception	Awareness
N1	9	.67	.83
N2	17	.83	.83
N3	26	1.00	1.00
N4	25	.83	1.00
N5	24	.67	.67
N6	11	.50	.67
N7	5	.83	.83
N8	5	.67	.75
N9	2	1.00	1.00
N10	4	.83	.75
N11	3	.50	.67
N12	3	.83	.75

The results show the relationship between the increase in the Broad Jump Test and the mean of the answers to the perception and awareness questionnaires. As the mean of the positive responses (on both perception and awareness) increases, the performance gains tend to be higher, indicating a potential positive correlation. This relationship is confirmed by Pearson's analysis, which shows a positive correlation between:

1. Motor test increase and mean perception: *R*=.73 (strong)
2. Motor test increase and average awareness: *R*=.59 (moderate)

Discussion

From the results obtained, it is evident that the improvement in strength, particularly in the Broad Jump Test, was significant. The average improvement of 124.7 cm in the Broad Jump Test and the highly significant statistical value (*P*= .002) support the effectiveness of the strength protocol applied. The Chi-Square analysis revealed several significant relationships: The first is between the 1P) 'Do you feel that this training programme makes you feel more energetic?' and question 1C) 'Did the training protocol help you recognise your strengths and areas for improvement in a more conscious way?' with a value of *P*= .028. Subsequently, there is a relationship between question 2P 'Do you feel motivated and/or enthusiastic about doing this training programme?' and question 2C 'Do you feel that using the protocol performed has made you more aware of how your body reacts to physical or mental effort?' with *P*= .020. The third relationship found is between the question 3P 'Having never done this training, do you feel fit to do it?' and question 2C 'Do you feel that using the protocol performed has made you more aware of how your body reacts to physical or mental effort?' with *P*< .001. Finally, the fourth and final significance is between the question 1P 'Do you feel that this training programme makes you feel more energetic?' and 3C 'Have you felt more aware of the impact of your actions (physical or mental) on others or your surroundings?' with *P*=.028.

The results show that the improvement in strength is not limited to performance aspects but has a positive impact on the subjective perception of the participants. This confirms the importance of considering not only physiological parameters, but also psychological variables when implementing protocols for young athletes. Previous studies have emphasised how increasing strength can positively influence self-efficacy and self-esteem, crucial aspects in psychophysical development at a developmental age.[21] Furthermore, the answers to the questionnaires show a high positive perception of the programme, both in terms of perception and awareness, creating a link between objective and subjective benefits. The integration of developmental strength protocols not only improves physical parameters but also helps to develop awareness and social-emotional skills in participants. The significant connection between the increase in perceived performance and increased awareness of one's own abilities (*P*=.028) highlights how training can serve as a self-assessment tool with the application of the awareness perception questionnaire. These results are consistent with the recommendations of the National Strength and Conditioning Association, which attributes psychological as well as physical benefits to resistance training.[22] The results suggest that the protocol not only fostered an improvement in physical performance but also supported the development of a greater awareness in the participants regarding their strengths and areas for improvement.

The significant relationships that emerged from the Chi-square test reinforce this connection: the link between feeling more energetic and awareness of one's strengths (*P*=.028) indicates that the positive perception of strength development contributes to the recognition of personal abilities. In particular, the more pronounced performance improvement could derive from physiological and neuromuscular factors, such as a different muscle fibre composition or greater effectiveness in intra- and inter-muscular coordination.[23] However, it is crucial to emphasise that the improvements observed are not limited to the physical sphere. The interactive and motivating training context played a crucial role in enhancing growth processes due to the proven evidence on perception and awareness, as indicated by the significant correlation between feeling motivated and an increased understanding of bodily responses to effort (*P*= .020). The latter suggests that a motivating training context is essential to stimulate learning and internalisation of psychophysical benefits.

The analysis of the Pearson correlation results shows that the strong correlation between the increase in the test and the perception-related answers (*R*= .73) implies that an increased ability to perceive and understand one's own movements is closely associated with improved performance. This finding confirms the importance of self-perception as a key factor in the development of motor skills. A moderate correlation between the increase in performance and awareness (*R*=.59) reflects a significant but less pronounced relationship with respect to perception. Awareness includes broader cognitive aspects, such as understanding why and how to perform certain movements or strategies. This result suggests that although awareness plays a relevant role, its impact may be mediated by more immediate factors, such as perception, or aspects related to context and external support. The protocol thus proved to be effective not only for improving physical strength, but also for promoting an active and aware lifestyle. The combination of quantitative and qualitative-quantitative data highlights how strength training can become a means to educate young people about the importance of movement, directing them towards a proactive prevention of their own health. These results support the adoption of similar protocols in sports and schools, with the aim of creating a positive impact in the psychophysical development of the subjects.

Practical Applications

This study confirms the value of strength training as an educational and training tool for young people, highlighting that it is not only a means to develop skills, but also an opportunity to increase awareness of one's own body and aptitudes. The implementation of resistance training protocols not only promote physical adaptations but also foster awareness of the connections between improvements and benefits. This connection emphasises how a verification of the also psychophysical effects of exercise can be applied in training protocols to motivate the athlete to the highest level. Despite the limited sample, the results obtained showed a high level of significance, which suggests that the concrete benefits that resistance training can offer to 10–12-year-olds, i.e. at a crucial stage in their growth, maturation and development process, is considerable. A further positive aspect that emerged was the decisive role of the subjects' perception and active involvement. The results of the questionnaires showed that the proposals applied were not only quantitatively effective but also created a positive and stimulating environment. Although the specific and limited sample represents a critical issue, the results of this study can offer valuable insights for planning activities

aimed at the overall development of performance that are more attuned to individual perceptions and opinions.

Limitations of the study

This study presents several limitations that should be acknowledged. First, the sample size was limited to 12 athletes, which may reduce the generalizability of the findings to larger populations. Second, the absence of a control group limits the ability to make causal inferences and to differentiate the observed effects from other potential confounding variables. Finally, the questionnaire was not administered after each training session, which might have restricted the ability to capture more precise and immediate feedback on the athletes' perceptions and responses to the interventions. Future research should address these limitations by including a larger sample, implementing a control group, and ensuring more frequent data collection to enhance the robustness and reliability of the findings.

Conclusions

The integration of qualitative tools, such as questionnaires, proved useful in better understanding the motivational dynamics and perceptions of young people, suggesting that emotional and cognitive engagement is essential to maximise the benefits of exercise aimed at strength development. Furthermore, the study introduces the use of performance data as a function of trainability in developmental age. However, further research with larger and more diverse samples will be required to generalise the evidence.

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Ethical Committee approval

The study was conducted in accordance with the Declaration of Helsinki. According to Regulation (EU) 536/2014 and Directive 2001/20/EC, research that poses minimal risks to participants may be exempt from formal ethical approval as it does not involve invasive or experimental interventions. In addition, according to Legislative Decree No. 211 of 24 June 2003, research that does not pose significant risks and is aimed solely at improving educational practices may be exempt from review and approval by the Institutional Review Board (IRB) or Ethics Committee.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

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Author-s contribution

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