PHYSICAL EDUCATION OF STUDENTS

ORIGINAL ARTICLE

Determining university students' cognitive structures and alternative concepts on striated muscle by word association test

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Abstract

Background and Study Aim Muscles are a set of topics for physical education and sports. Cognitive structure and alternative concepts of students should be diagnosed about striated muscles, which are very rich in terms of abstract concepts. The aim of this research is to determine the cognitive structures, alternative concepts and conceptual change process of university students on striated muscle with the word association test.

Material and Methods 50 students who took physiology course in Selcuk University physical education and sports teaching 2nd year participated in the research. The research was designed with a single group pretest posttest weak experimental design. The students were given a pre-test Word Association Test (WAT), then the subject of striated muscles in the training information curriculum was explained, and then WAT was re-applied as a post-test. As a result of the tests applied, the frequencies of the answer words given by the students to 11 key concepts were calculated and the cut-off points were determined and concept networks were created. In addition, the sentences formed by the students about these concepts were examined in terms of misconceptions.

Results We found that the students produced 44 answer words in the pre-test and 64 in the post-test, and the frequency of many concepts increased in the post-test compared to the pre-test. However, an increase in the knowledge level and concept associations of the students at the desired level was not observed. In addition, we determined that although the students' misconceptions about striated muscle decreased in the post-test compared to the pre-test, they still continued, and the students generally had unscientific or superficial knowledge in both tests.

Conclusions As a result of the research, it was determined that there was a significant change in the cognitive structure of the students about the skeletal muscle, although it was not at a sufficient level, and their misconceptions were reduced. It has been concluded that the WAT is an important alternative assessment tool to determine the conceptual development in preliminary and post-knowledge, as well as a strategy that can be used to ensure meaningful learning and conceptual change.

Keywords: word association test, physiology, training, striated muscle, misconceptions

Introduction

One of the most important features of today's information and technology age is to reach the desired information instantly and easily. However, this ease of access to information brings with it some disadvantages and makes it difficult to question the accuracy of the information. As a matter of fact, when we assume how much information facilitates human life in the renewed and developing world, learning the concepts correctly can be considered as one of the most critical steps to be taken on this path. Because a wrongly learned or associated concept may cause further inhibition in new learning, resist change or delay meaningful learning [1, 2]. Education, which can deeply affect and change human life from the beginning to the end, plays a major role in the correct learning of concepts and the formation of cognitive structuring when applied deliberately.

The concept is defined as "the mental structure or representation formed as a result of grouping objects, events, facts and ideas according to their similar characteristics" [3]. The Turkish Language Institution, on the other hand, defined the concept as "the abstract and general design of an object or thought in the mind" [4]. Concepts, the common names given to groups when entities, events, people, and thoughts, are grouped according to their similarities. The concept is not concrete objects, events or entities, but abstract thought units that can be reached by gathering them under certain groups. Concepts do not exist in the real world, but in people's thoughts. The absence of concepts, which are indispensable elements of learning, means that information cannot be classified in a systematic way and this information cannot be transferred to others [5]. Concepts are the basis of knowledge, the relations between concepts constitute scientific principles. For this reason, with

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the effective acquisition of the basic concepts of a discipline, it is ensured that individuals acquire the mental skills needed to understand the principles of that discipline and to find solutions to problems in this direction [6]. While some concepts may change according to people's thoughts and mental structures, some concepts evoke approximately the same images in all minds. This is a phenomenon related to whether the same meaning is attributed to the concept during the formation phase of the concepts. For example, while everyone attributes similar meanings to the concept of electricity, the meanings attributed to some abstract concepts such as force and power may vary according to the individual [7]. According to cognitive learning theory, students generate their own meanings for concepts based on their background, attitudes, abilities and experiences in the educational process. Newly learned meanings are then actively associated with the student's previous knowledge and concepts. However, sometimes the meanings produced in the process of gaining knowledge can be quite different from what is intended. In other words students' ideas about the subject may differ from the source being taught, and these different understandings emerge as misconceptions [8]. The researcher [9], who defines the scientifically erroneous thoughts and understandings of the students about events and situations as misconceptions, uses the expressions "he wears a concept mask, but it is not the concept behind the mask, it is a mistake in the appearance of the concept". Misconceptions are considered very dangerous during education as they overshadow and blur the real concepts related to the same phenomenon. It is thought that it is much better for people to have no concept and knowledge about a subject than to have misconceptions on that subject [9].

Ausbel's statement, "the most important and only factor affecting learning is what the student already knows" [10], the pioneer of the constructivist approach, can be considered as the biggest proof of how misconceptions have a great impact on learning. As in the education of every lesson and subject, misconceptions of the students come at the beginning of the factors that make the teaching process of the lessons containing science subjects difficult [11]. Because, in order for students to learn meaningfully, it is important to construct concepts and the relationship between concepts cognitively correctly, and to establish semantic ties rather than mere definitions of concepts during their storage in long-term memory [12]. At this point, one of the main objectives should be to identify misconceptions, in other words, alternative thoughts and replace them with scientific concepts. For this reason, reaching the knowledge and concepts that students have before, determining and revising alternative perspectives existing in students should be accepted as a prerequisite for the realization of meaningful learning [12, 13].

Concepts usually have an abstract feature and are not found in the physical world, but in the mindset of the person. It is important in this respect to pay attention to the cognitive world of the student in gaining the concept [12]. In this context, it should be examined whether the relationship between the important concepts that university students will use throughout their professional life and that are in their memories, and if there are any misconceptions about these concepts. There are many alternative measurement and evaluation techniques used to reveal the relational schema and misconceptions of the concepts in students' memories. Among these techniques, there are word association tests (WAT), which is one of the oldest and most common techniques used to analyze the cognitive structure of individuals, the relationships between concepts in this structure and the knowledge network, and to reveal whether the relationships between the concepts in long-term memory are sufficient or not. [14]. The word association test is defined as "a measurement and evaluation method that tries to determine the level of meaning and competence of the information and relationships that arise in the consciousness of the participants towards certain events and phenomena" [15]. The word association test has been popular in many studies for many years as one of the most effective techniques used to determine the relationships and connections between concepts in determining learning or misconceptions in education. When the relevant literature is examined, it is observed that WATs are used to determine students' cognitive structures [16-20], their conceptual changes [21-24] and misconceptions (alternative concepts) [12, 25-29] and to obtain data. In addition, it was determined that Word Association Test (WAT) research is of interest in the fields of defining concepts in science [22, 25, 29, 30] and social sciences [17, 31, 32], in which university students were chosen as the research group generally focused on teacher candidates [15, 17, 30, 33] in the departments of education faculties.

Purpose of the research

As in many fields of education, the importance given to exercise, physical education and sports, training information, physiological strength, strength endurance increase and training a better athlete shows that more focus should be placed on the correct learning and use of the scientific concepts learned in this subject. Physiology and training knowledge have a very rich content in terms of abstract concepts, as their infrastructure is based on science [34], and concepts should be learned by students by associating them in a meaningful way, not by memorizing. Because, knowing the subject of

muscles in detail in Physical Education and Sports Teaching department courses is of great importance in terms of using this information by transferring it in all kinds of professional studies and producing new knowledge and experiences by associating it with different fields. Because the basic approach of both physiology and training courses is not only to provide information about situations, concepts and events, but to train students who are equipped with concepts and skills, who produce and use knowledge. This important issue reveals the importance of the function of knowledge, permanence of concepts and cognitive structure, which is a fundamental phenomenon for candidates who will be both teachers and athletes. The hypothesis of the research was determined the following – "WAT, which is a different visual material, is an effective assessment scale in revealing students' cognitive structures and alternative concepts on the subject where abstract concepts are concentrated." The aim of the research is to determine university students' i) cognitive structures, ii), conceptual change process, iii) alternative concepts (misconceptions) about striated muscle, by word association test.

Considering that the concepts of striated muscles within the scope of this research are in a close relationship with each other physical education and sports department. They are of great importance to reveal existing misconceptions by looking at students' conceptual associations, to determine their cognitive structures about these concepts and to determine the conceptual links between them, and to have the opportunity to use appropriate methods and techniques related to the subject in order to ensure students' meaningful learning. The fact that no study has been found in the literature on the determination of students' cognitive structures for the concepts of muscles, which is a basic subject for physiology and training knowledge courses, and the correction of misconceptions, reveals the original value and added value of this research.

Materials and Methods

Participants

The research group consists of 50 students, who are studying in the 2nd year of the Physical Education and Sports Teaching Department of the Faculty of Sports Sciences of Selçuk University, who have taken a physiology course before and will take a training information course. The research group was determined by criterion sampling method. The criterion sampling method is to create a sample group that meets the criteria previously prepared for the research by the researcher [36].

Research Design

This research is a quantitative research feature and was designed with a single-group pre-test post-test weak experimental design from the experimental models [35]. The research carried out in two stages is presented in Figure 1 as an application.

Data Collection Tools

The Word Association Test (WAT) was used as a data collection tool in the study. For the WAT, 11 key concepts were used and each of the key concepts was written 10 times on a single page. These key concepts (Muscle, Sarcomere, Oxygen, ATP, Mitochondria, Actin, Myosin, Hypertrophy, Atrophy, Motor Unit, Sarcoplasm) were determined according to the help of the experts and the course curriculum and achievements. In the pre-test and post-test application, the students were expected to write the pre-answer word that came to mind within 60 seconds for each of the key concepts. In addition, students were asked to write a sentence related to the key concept at the bottom of the KIT form page in order to determine whether the students knew the key concepts in accordance with the curriculum content, whether there were alternative concepts, and whether the answer words they wrote were a product of superficial connotation [37]. A pilot application was carried out by explaining the KIT to the students before the real applications were made.

Statistical Analysis

In the word association test, the data were evaluated by looking at and comparing the number of words produced for the key concept, the quality of the word (related to the key concept), and word associations [38, 39]. Due to the large number of key concepts given for WAT in this study, the first group consisting of the concepts of sarcoplasm, sarcomere, oxygen, ATP and mitochondria and the second group consisting of the concepts of actin, myosin, hypertrophy, atrophy, motor unit, muscle were divided into two groups. The answer words developed by the students for each key concept in the pre-test and post-test were examined and their frequencies were calculated. Of these answer words, those with 8 or more repetitions are tabulated. Then, the upper and lower limits of the answer words in this table were determined, and the cut-off points were determined by the cut-off point technique [16,

Groups	Pretest	Process	Posttest
G	Word Association Test (WAT)	Application of the Training Information Curriculum	Word Association Test (WAT)

Figure 1. Single Group Pretest - Posttest Pattern Application

25]. 6 breakpoint ranges were determined for the pretest and posttest. In order to see the concept relationships for each level, a separate concept network was created and the connections made according to all breakpoints were visualized in the final concept network. The breakpoints are colored according to the frequency range of the answers given by the students to the keywords. 35 and above are colored black, 29-34 blue, 23-28 green, 17-22 purple, 11-16 red and 5-10 brown. The sentences written by the students for key concepts were examined and evaluated by grouping them under the headings of sentence examples containing scientific information, non-scientific or superficial information, and misconceptions.

Results

After receiving the feedback from the students for the key concepts, the answers given to each key concept were determined in the pre-test and post-test, and frequency tables were prepared (Table 1 and Table 2).

Among the first group concepts, the first three concepts with the highest frequency in the pre-test were ATP (35 energy response words), mitochondria (31 energy, 26 ATP response words) and oxygen (26 aerobic response words). Among the second group concepts, the highest frequency concepts are hypertrophy (30 muscle response words), atrophy (30 shrinkage, 28 muscle response words), actin (26 muscles, 26 myosin response words), myosin (26 muscle response words) and muscle (26 movement response words) concepts (Table 1).

The words associated with the first group of keywords (Sarcoplasma, Sarcomere, Oxygen, ATP, Mitochondria) in the pre-test were analyzed one by one, starting from the cut-off point 35 and above, and conceptual networks were drawn. The concept network in Figure 2 was obtained as a result of the examinations made between the last cut-off point 5-10.

The first key concept to emerge at breakpoint 35 and above was ATP. The answer word that revealed the ATP key concept at this level was energy (f= 35). In addition to the ATP switch concept at the cut-off point 29-34, the mitochondria switch concept emerged at this level. The students associated the key concept of mitochondria with the word energy. At the 23-28 cut-off point, the key concepts of mitochondria and oxygen emerged mitochondria were associated with ATP (f= 26) and oxygen with aerobic (f= 26) response words. When the range of 17-22 is examined, although the frequency numbers decreased, all key concepts emerged. At this cut-off point, a bilateral relationship was established between the sarcomere and the sarcoplasm with the word muscle response. In addition, a triple relationship was established between the key concepts of ATP, mitochondria and oxygen by associating the oxygen key concept with the energy response word. It is seen that the number of answer words increasing in the range of 11-16 cuts and there are many bilateral relations between the words. The key concept of oxygen has led to the establishment of a connection between ATP and mitochondria, and the key concept of mitochondria between the carbohydrate, fat, protein response words and the key concept of ATP. As a result of the 5-10 cut-off points, the final form of the concept map was formed (Figure 1), the energy response word was associated with the sarcoplasm, forming a quadruple bond with the key concepts of oxygen, ATP, mitochondria. A relationship was established between ATP and oxygen through aerobic and anaerobic response words.

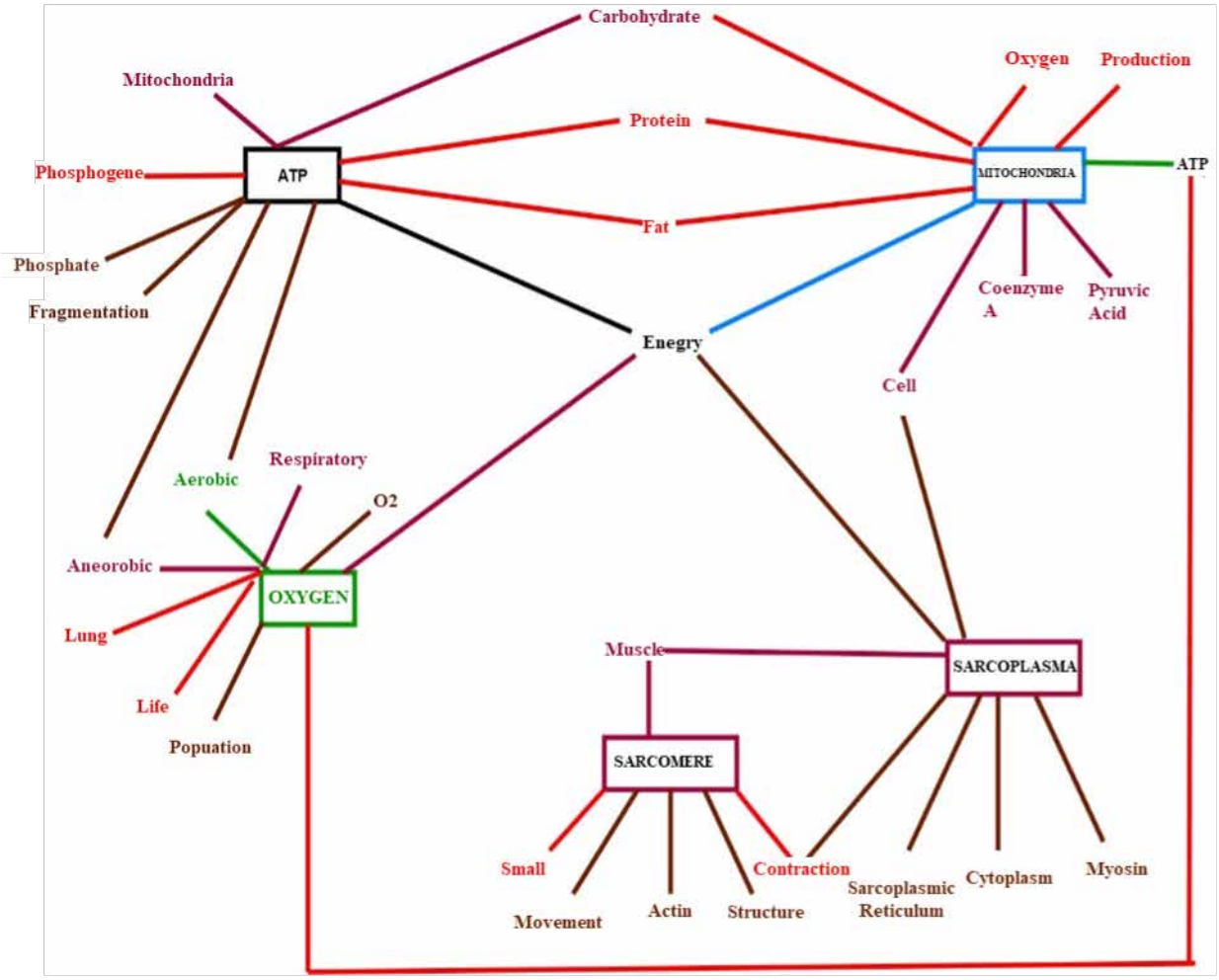
The words associated with the second group of keywords (Actin, Myosin, Hypertrophy, Atrophy, Motor Unit, Muscle) were examined one by one, starting from the cut-off point 29-34 in the pre-test, and conceptual networks were drawn (since there was no key concept answered with a frequency of 35 and above). The concept network in Figure 3 was obtained as a result of the examinations made between the last cut-off point 5-10.

They wrote answer words for the key concepts of hypertrophy and atrophy in the range of 29-34. While the key concept of hypertrophy was given the word muscle response, the concept of atrophy was given the answer shrinkage. While the key concepts of actin, myosin and muscle were revealed for the first time in the range of 23-28, the students associated the key concepts of atrophy, actin, myosin with the common muscle response word. Again, in this period, the key concept of muscle formed an independent link with the word movement response, the key concept of actin, the word myosin, and the key concept of hypertrophy with the word growth. All key concepts emerged in the 17-22 range. The key concept actin, myosin, muscle has a common relationship with the contractile response word. While an increase was observed in the number of answer words between the cut-off point 11-16, it was observed that there was a decrease in the frequencies. At this level, it is seen that many key concepts are related to each other. For example, while the key concept of hypertrophy was associated with the contractile response word and the key concepts of muscle, actin, myosin, the key concepts of actin and myosin motor unit met in the word movement. In the frequency table answered between 5-10, they wrote fibril, heart and nerve to the muscle key concept, force and contraction to the motor unit key concept, atp as common to the myosin and actin key concepts, troponin and energy to the myosin key concept, and tropomyosin to the actin concept.

In the post-test, the three concepts with the highest frequency from the first group of concepts

Table 1. Answer Words and Frequencies of Key Concepts Used as a Pre-Test

Answer words	Sarcoplasma	Sarcomere	Oxygen	ATP	Mitochondria	Actin	Myosin	Hypertrophy	Atrophy	Engine unit	Muscle
Movement	-	8	-	-	-	12	14	-	-	13	26
Contraction	9	13	-	-	-	21	13	13	10	9	21
Cytoplasm	9	-	-	-	-	-	-	-	-	-	-
Sarcoplasmic Reticulum	8	-	-	-	-	-	-	-	-	-	-
Myosin	8	-	-	-	-	26	-		8	-	10
Protein	-	-	-	15	10	12			10	-	8
Muscle	17	21	-	-	-	26	26	30	28	20	-
Small	-	12	-	-	-	-		-	-	-	-
Actin	-	8	-	-	-	-	22	-	-	-	-
Structure	-	8	-	-	-	-		-	-	-	-
Energy	8	-	17	35	31	-	9	-	-	-	-
Aerobic	-	-	26	10	-	-	-	-	-	-	-
Anaerobic	-	-	19	10	-	-	-	-	-	-	-
Respiratory	-	-	19	-	-	-	-	-		-	-
Lung	-	-	15	-	-	-	-	-	-	-	-
Life	-	-	13	-	-	-	-	-	-	-	-
ATP	-	-	12	-	26	8	9	-	-	-	-
Breath	-	-	9	-	-	-	-	-	-	-	-
O2	-	-	9	-	-	-		-	-	-	-
Carbohydrate	-	-	-	20	14	-	-	-	-	-	-
Mitochondria	-	-	-	20	-	-	-	-	-	-	-
Fat	-	-	-	15	11	-	-	-	-	-	-
Phosphogene	-	-	-	12	-	-	-	-	-	-	-
Phosphate	-	-	-	10	-	-	-	-	-	-	-
Fragmentation	-	-	-	9	-	-	-	-	-	-	-
Cell	10	-	-	-	20	-	-	-	-	-	-
Pyruvic Acid	-	-	-	-	18	-	-	-	-	-	-
Oxygen	-	-	-	-	16	-	-	-	-	-	-
Coenzyme A	-	-	-	-	19	-	-	-	-	-	-
Production	-	-	-	-	12	-	-	-	-	-	-
Relaxation	-	-	-	-	-	14	13	-	-	-	-
Tropomyosin	-	-	-	-	-	8	-	-	-	-	-
Troponin	-	-	-	-	-	-	8	-	-	-	-
Force	-	-	-	-	-	-	-	10	-	8	11
Growth	-	-	-	-	-	-	-	28	-	-	-
Training	-	-	-	-	-	-	-	13	8	-	-
Strength	-	-	-	-	-	-	-	10	-	-	11
Development	-	-	-	-	-	-	-	9	-	-	-
Shrinkage	-	-	-	-	-	-	-	-	30	-	-
Straight	-	-	-	-	-	-	-	-	-	-	13
Striped	-	-	-	-	-	-	-	-	-	-	17
Heart	-	-	-	-	-	-	-	-	-	-	10
Fibril	-		-	-	-	-	-	-	-	-	9
Nerve	-	-	-	-	-	-	-	-	-	13	-



35 and Above
Between 29 – 34
Between 23 – 28
Between 17 – 22
Between 11 – 16
Between 5 – 10

Figure 2. Concept Network Created by First Group Keywords (Pre-Test)

were ATP (38 muscle response words), mitochondria (38 energy response words) and sarcoplasm (29 muscle response words), in the second group of concepts – hypertrophy (37 muscle response words), actin (37 actin, 36 muscle response words) and myosin (35 actin response words) concepts (Table 2).

The words associated with the first group of keywords (sarcoplasma, Sarcomere, Oxygen, ATP, Mitochondria) in the posttest were analyzed one by one, starting from the cut-off point 35 and above, and conceptual networks were drawn. The concept network in Figure 4 was obtained as a result of the examinations made between the last cut-off point 5-10.

The key concepts that emerged at breakpoint 35 and above were ATP and mitochondria. The answer word that emerged in both concepts was energy (f=38). The cut-off point is associated with the sarcoplasma muscle response word between 29-34 and the concept has been added to the network. Again at this level, the phosphate response word was produced for the ATP key concept. In the 23-28 range, the key concepts of oxygen, sarcomere were added to the network, the concepts of sarcoplasm and mitochondria were associated with the cell response word, and the concepts of actin, myosin, contraction and ATP emerged independently. Although answer words were produced for many key concepts at the 17-22 cut point, no new key concept was added to the network. Mitochondria and adenosine for the key concept ATP, organelle response words for the key concept mitochondria, cytoplasm for the key concept sarcoplasm, and aerobic response words for the oxygen key concept have emerged. Although the answer words given

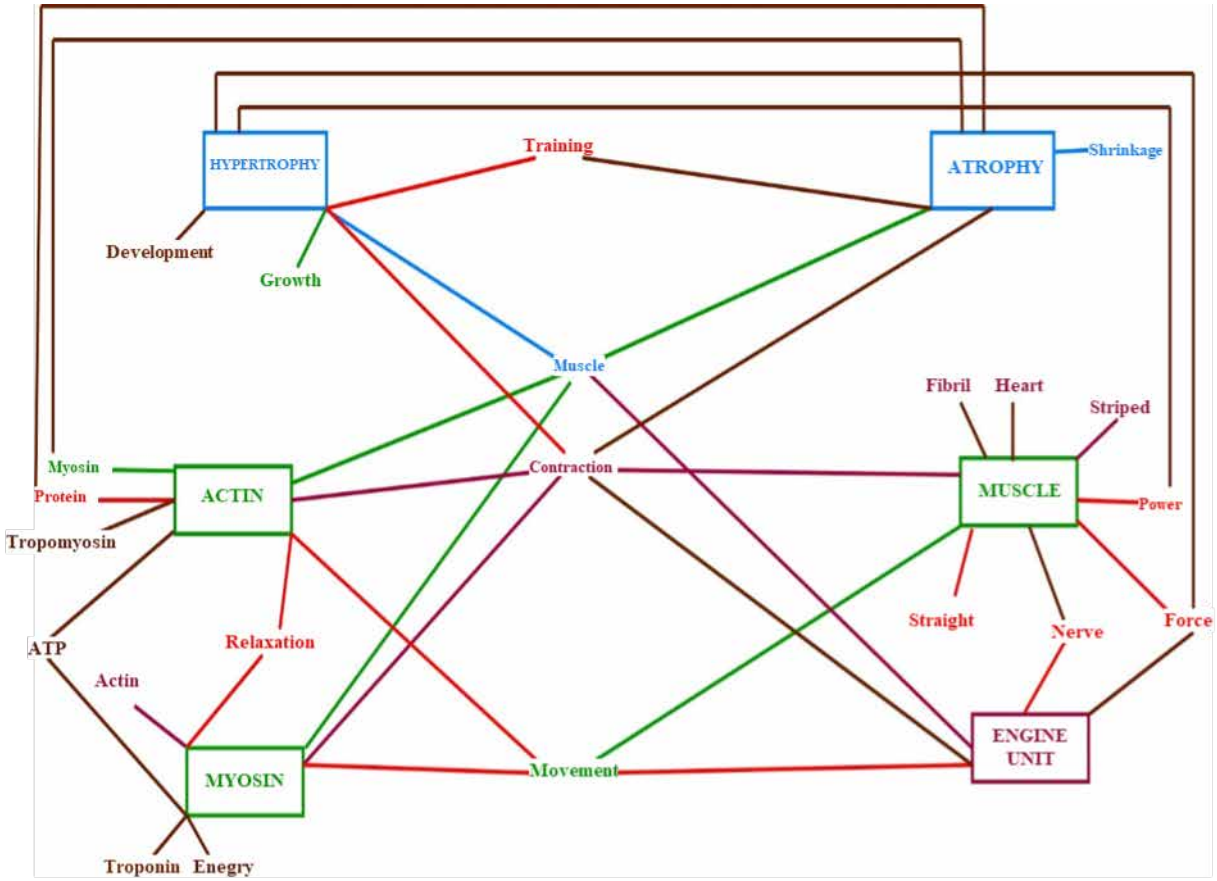


Figure 3. Concept Network Created with Second Group Keywords (Pre-Test)

by the students between the breakpoints of 11-16 were shot, it was observed that a sufficient level of correlation could not be established between the key concepts. In the 5-10 cut-off note, the ATP key concept forms a common link with the cell response word and the mitochondria and sarcoplasm key concepts. The sarcoplasma keyword is associated with the actin and myosin response words and the sarcomere keyword.

The words associated with the second group of key concepts (Actin, Myosin, Hypertrophy, Atrophy, Motor Unit, Muscle) were analyzed one by one, starting from the cut-off point 35 and above in the posttest, and conceptual networks were drawn. As a result of the examinations made between the last cut-off point 5-10, the final concept network in Figure 5 was obtained.

The key concepts of hypertrophy, actin, and myosin have emerged at the cut-off point of 35 and above. The students wrote a muscle response word for the key concepts of hypertrophy and actin and formed a relationship between these two key concepts. In the range of 29-34, the key concepts of motor unit and atrophy emerged and a meaningful connection was established by associating the key concepts of hypertrophy, actin, myosin with the word muscle. No new key concepts were added to the network, with the breakpoint in the range of 23-28, only shrinkage and contraction responses emerged. The last key concept, muscle, with the cut-off point in the 17-22 range, emerged and many low-frequency response words were added to the network. A high correlation was established between many key concepts at cut points 11-16 and many answer words were added to the network. At the 5-10 cut points, all key concepts were answered except for the muscle keyword and these words were added to the network (Figure 5).

The sentences produced by the students for key concepts before and after the education were grouped as scientific knowledge, non-scientific and superficial, containing misconceptions and presented in Table 3 and Table 4.

Table 2. Answer Words and Frequencies of Key Concepts Used as Post-Test

Answer words	Sarcoplasma	Sarcomere	Oxygen	ATP	Mitochondria	Actin	Myosin	Hypertrophy	Atrophy	Engine unit	Muscle
Contraction	14	23	-	-	-	25	27	-	-	-	20
Actin	10	27	-	-	-	-	35	-	-	-	17
Myosin	10	26	-	-	-	37	-	-	-	-	17
Myofibril	9	-	-	-	-	10	8	-	-	-	16
Muscle	29	23	-	11	-	36	33	37	30	33	-
Z Band	-	15	-	-	-						
Relaxation	-	12	-	-	-	-	13	-	-	-	-
Movement	-	10	-	-	-	10	-	-	-	10	-
A Band	-	10	-	-	-				-		
Structure	-	9	-	-	-				-		
Respiratory	-	-	23	-	-				-		
Aerobic	-	-	21	-	13				-		
Energy	-	-	13	38	38				-		
Anaerobic	-	-	12	-	-				-		
Gas	-	-	12	-	-				-		
Lung	-	-	11	-	-				-		
Capacity	-	-	11	-	-				-		
Hemoglobin	-	-	11	-	-				-		
O2	-	-	11	-	-				-		
Life	-	-	10	-	-				-		
Phosphate	-	-	-	30	-				-		
Adenosine	-	-	-	22	-				-		
Mitochondria	-	-	-	17	-				-		
Phosphogene	-	-	-	15	-				-		
Carbohydrate	-	-	-	12	-				-		
Fat	-	-	-	10	-				-		
Cell	28	-	-	9	33	-	-	-	11	9	-
System	-	-	-	9	-				-		
ATP	8	-	-	-	23	10	16	-	-	-	-
Organelle	-	-	-	-	17	-	-	-	8	-	-
Cytoplasm	17	-	-	-	15	-	-	-	-	-	
Oxygen	-	-	-	-	15	-	-	-	-	-	
Production	-	-	-	-	12	-	-	-	-	-	
Liquid	12	-	-	-	-	-	-	-	-	-	
Sarcomere	9	-	-	-	-	-	-	-	-	-	
Protein	-	-	-	-	-	21	21	-	-	-	-
Troponin	-	-	-	-	-	18	16	-	-	-	-
Tropomyosin	-	-	-	-	-	17	16	-	-	-	-
Floating Flament	-	-	-	-	-	11	-	-	-	-	-
Hold	-	-	-	-	-	-	9	-	-	-	-

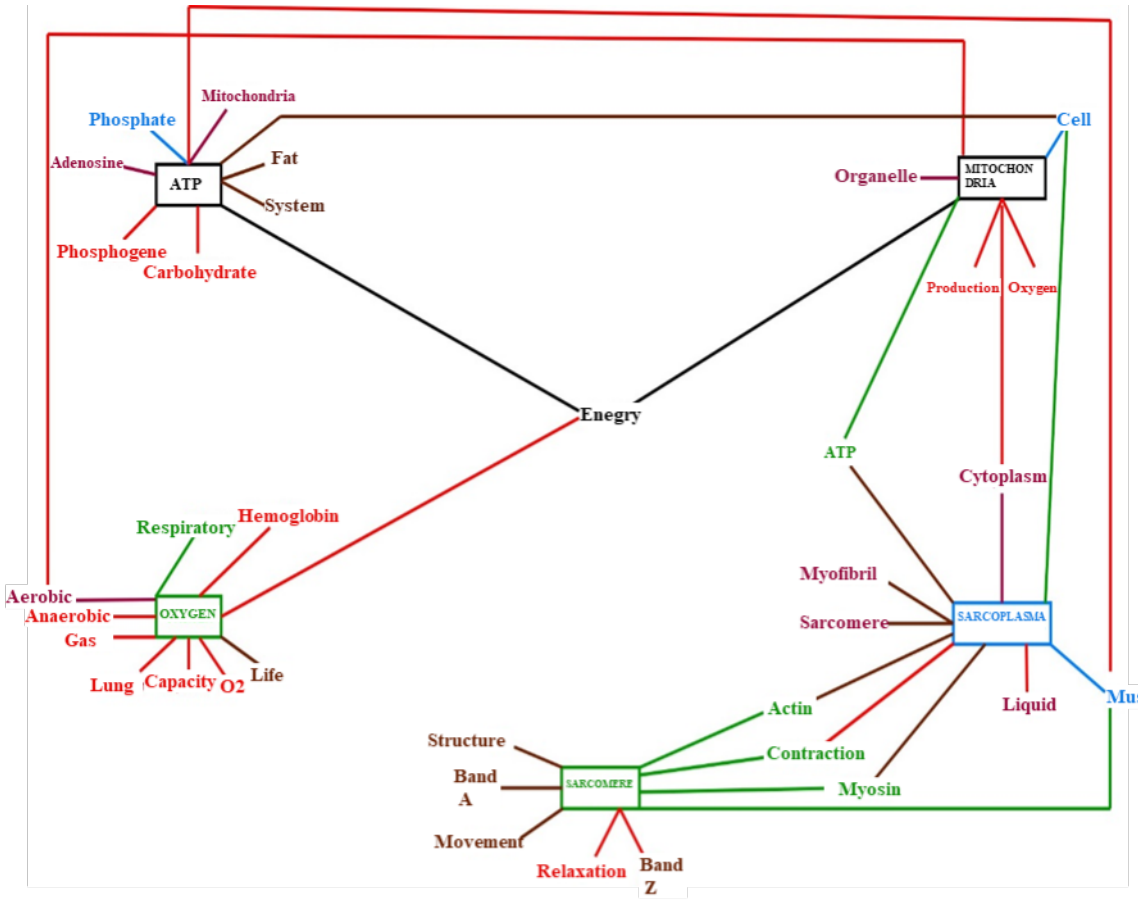
Table 2 (continued).

Answer words	Sarcoplasma	Sarcomere	Oxygen	ATP	Mitochondria	Actin	Myosin	Hypertrophy	Atrophy	Engine unit	Muscle
Growth	-	-	-	-	-	-	-	31	-	-	-
Force	-	-	-	-	-	-	-	21	-	-	14
Development	-	-	--	-	-	-	-	14		-	-
Fiber	-	-	-	-	-	-	-	11		16	13
Strength	-	-	-	-	-	-	-	11		-	-
Training	-	-	-	-	-	-	-	11		-	-
Capillary	-	-	-	-	-	-	-	9		-	-
Increase	-	-	-	-	-	-	-	9		-	-
Nerve	-	-	-	-	-	-	-	8		21	-
Shrinkage	-	-	-	-	-	-	-	-	23	-	-
Lack of training	-	-	-	-	-	-	-	-	11	-	-
Loss	-	-	-	-	-	-	-	--	11	-	--
Tissue	-	-	-	-	-	-	-	-	10	-	-
Reduction	-	-	-	-	-	-	-	-	10	-	-
Weakness	-	-	-	-	-	-	-	-	8	-	-
Hypertrophy	-	-	-	-	-	-	-	-	9	-	-
Neuron	-	-	-	-	-	-	-	-	-	18	-
Axon	-	-	-	-	-	-	-	-	-	17	-
Striped	-	-	-	-	-	-	-	-	-	14	20
Warning	-	-	-	-	-	-	-	-	-	13	-
Motor Unit	-	-	-	-	-	-	-	-	-	11	-
Fast Type	-	-	-	-	-	-	-	--	-	-	14
Slow Type	-	-	-	-	-	-	-	-	-	-	13
Straight	-	-	-	-	-	-	-	-	-	-	17

When the pre-test answers of the sentences written by the students about the key concepts were examined. It was observed that the answers were generally similar to each other and most of them consisted of non-scientific and superficial answers (Table 3), and this situation continued to decrease in the post-test (Table 4). In addition, it was observed that in the post-test, sentences similar to the sentences in the pre-test were formed and that the students in general could not produce sentences related to the key concepts of sarcoplasm and motor unit, and therefore, the relevant places in the table were generally left blank. In addition, it was determined that the misconceptions were significantly reduced in the post-test compared to the pre-test, and the frequencies of the sentences containing scientific information in both tables were found to be quite low.

Discussion

In this study, we determined that the pre-application knowledge of the students on striated muscles was insufficient. After the lessons, we saw that students established more meaningful relationships between concepts, an increase in the number of answer words and a decrease in misconceptions. There is a significant increase in the number of answer words in the post-test compared to the number of answer words in the pre-test. While the students produced 44 answer words in the pre-test for 11 key concepts, they produced 64 answer words in the post-test (Table 1 and Table 2). The frequency table showed us that the associations between concepts became more semantic in the post-test compared to the pre-test and that the relationships between concepts increased. Because, as the level of understanding of the concepts

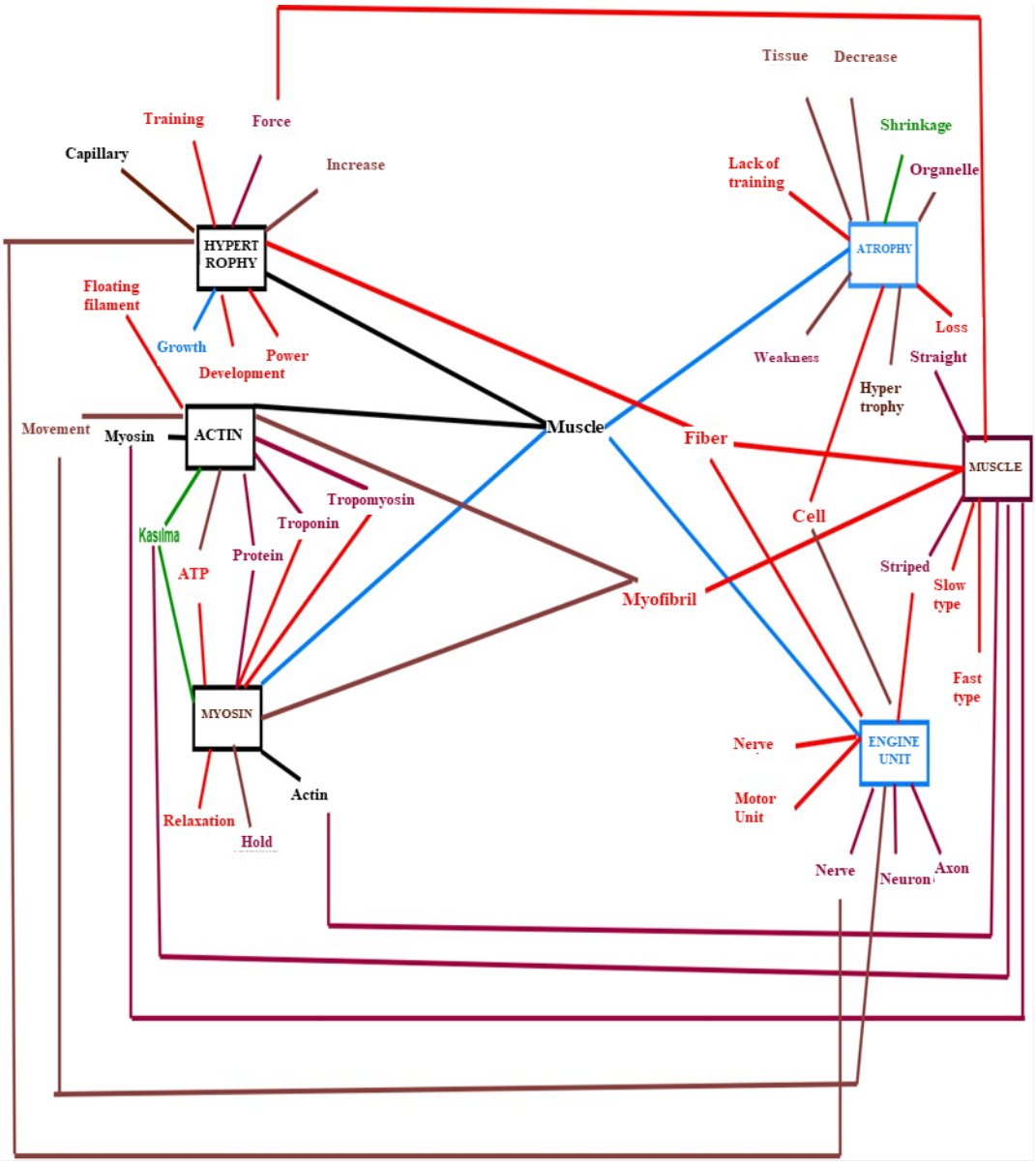


35 and Above
Between 29 – 34
Between 23 – 28
Between 17 – 22
Between 11 – 16
Between 5 – 10

Figure 4. Concept Network Created by First Group Keywords (Post-Test)

increases, it is seen in different studies that the level of association with other concepts also increases [14, 29]. The fact that students' associating the answer words and key concepts with each other increased in the posttest, resulting in the formation of new and different concept networks (Figure 2- Figure 5).

However, although there was an increase, it was determined that the knowledge levels of the students were below what was expected in both the first and last test, and that many students still could not achieve meaningful learning and that there was a problem in cognitive mapping of the concepts related to striated muscles. This determination also emerges from the sentences made by the students about the key concepts within the scope of the research [Table 3 and Table 4]. It was determined that the sentences made by the students about the key concepts generally contain unscientific or superficial information, the misconceptions found in the pre-test decreased in the post-test after the training knowledge lesson, and this decrease generally shifted to the sentences containing non-scientific or superficial information, not in favor of the sentences containing scientific information. In fact, most of the students could not produce sentences for the key concepts of sarcoplasm and motor unit. A researcher doing research on concepts considers that students' inability to produce a meaningful sentence about key concepts is an indication that these concepts are not learned at the conceptual level and meaningfully [22]. Another researcher stated that the high number of concepts that students left blank and the sentences produced with non-scientific or superficial information as a sign that students have a limited amount of qualified information about these words [30]. In the study examining the cognitive structure of the concepts of acceleration, friction force and inertia, it was revealed that the students generally used scientific and non-scientific knowledge fragments together when explaining these concepts and the cognitive structures of the students changed according to



35 and Above
Between 29 – 34
Between 23 – 28
Between 17 – 22
Between 11 – 16
Between 5 – 10

Figure 5. Concept Network Created by Second Group Keywords (Post-Test)

these sentences [20]. A similar finding emerged in the WAT research conducted for the concepts of support and movement system, and it was stated that the sentences written by the students were generally those containing superficial information or misconceptions, and the number of sentences left blank was intense [29]. Again, the same research has proven that secondary school students have misconceptions about concepts such as muscle, skeleton and joint and that their knowledge of keywords is mostly superficial.

Despite the different characteristics of the participants, learning areas and topics, it is observed that the results obtained in the studies on concept association, meaningful learning and the determination of cognitive structures related to alternative concepts are in line with the findings of our research and our findings are supported. A researcher applied WAT as a pre-test and post-test in his research on investigating the cognitive structures of high school students on the basic components of living things, and found that although the frequency values of the students in the post-test were higher than in the pre-test, a meaningful learning did not

Table 3. Related Sentence Table Given to Key Concepts by Students as a Pre-Test

Key Concepts	Sentence Examples Containing Scientific Information	Examples of Sentences Containing Unscientific or Superficial Information	Sentence Examples Containing Misconceptions
MUSCLE	-Muscle contraction attaches to actin myosin and pulls troponin, contracting by stimulating tropomyosin. -Muscles are structures made up of organic living elements that keep us alive and well. Muscles are divided into striated muscles, smooth muscles, cardiac muscle.	-Muscles allow us to move. -It is our source of action. -Muscle grows. -Muscles are important for appearance.	-Carbohydrates are stored in the liver, one of the types of muscle. -Muscle is for movement only.
SARCOME	-It is the smallest unit of muscle that can contract. -The smallest unit of muscle contraction by attaching threads to actin and myosin. -It contains muscle proteins in its structure.	-Sarcomere is related to contraction. -They build muscle. -They are effective in the work of the muscles.	-The smallest muscle. -Effective in increasing the length of the muscle. -The smallest structure of the muscle.
OXYGEN	-The most important gas necessary for the continuation of life. -O2 allows us to burn food and turn it into energy. - If the capacity increases, the endurance increases.	-Used with breathing. -It keeps our life going. -We cannot live without oxygen. -It is important for the energy system.	-The air we use while exercising. -Anaerobic training is oxygen-free training.
ATP	-Energy is provided from atp. -It is obtained by breathing. -It is ready energy in anaerobic training.	-There is energy -Adenosine Triphosphate. -ATP is the energy in the body.	-ATP are endless energy stores. -ATP develops with long-term training.
MITOCHONDRY	-Organelle that provides energy production in the cell. -The place where energy is created after the nutrients become suitable for burning.	-The energy production center in the cell. -Produces ATP. -Cell building block.	-It is the respiratory production center. -Atp produces mitochondria. -Division system
ACTIN	- Allows muscle contraction and relaxation. - It provides energy generation with the sliding filament theory by pulling with myosin inside the cell. -Thin threads that provide contraction.	-Muscle Protein -It is in the muscle. -Works with a tie.	-One of the muscle units. -Contraction occurs only with actin. -Helps in muscle production.
MYOSİN	-It allows the muscle to contract and relax. -It provides the movement of cells. -Thin threads that provide contraction.	-It has a role in muscle contraction. -Works in the muscle. -It works systematically.	-Motor nervous system -It is effective in muscle formation. -Muscle unit.
HYPERTROPHY	-Volumetric growth of muscles. -Increase in muscle mass. -Increase in muscle volume with increased capillary.	-It develops with weight training. -We should exercise. -Muscle growth.	-Increase in muscle fibers. -Increase in muscle cells. -Training is enough.

Table 3 (continued).

Key Concepts	Sentence Examples Containing Scientific Information	Examples of Sentences Containing Unscientific or Superficial Information	Sentence Examples Containing Misconceptions
ATROPHY	-The shrinkage of a tissue, cell or a cell for some reason. -The loss of muscle volume when training is stopped. -Reduction in muscle after aging.	-Muscle loss -Muscle shrinkage -Muscle change	-Muscle wasting -Muscle growth -Muscle protein
ENGINE UNIT	-Nöronlar tarafından uyarılma. -Çizgili kas lifleri ve nöronlardan oluşur. -Akson nöronlar içerisinde yer alır.	-Transmission center -Arousal occurs.	
SARCOPLASMA	-Fluid in the muscle cell -Muscle cytoplasm		

Table 4. Related Sentence Table Given to Key Concepts by Students as a Post-Test

Key Concepts	Sentence Examples Containing Scientific Information	Examples of Sentences Containing Unscientific or Superficial Information	Sentence Examples Containing Misconceptions
MUSCLE	-Organ that provides movement by contraction in humans and animals -Gives shape by sticking on the skeleton. -Muscles are divided into striated muscles, smooth muscles, cardiac muscle.	-Muscles move -Muscles can both enlarge and shrink. -Muscles show people's physique properly.	
SARCOME	-It is the smallest unit of muscle that can contract. -Located between two Z lines. -It contains muscle proteins in its structure. -It contains muscle proteins that are involved in the contraction of the muscle.	-The unit in which the contraction takes place. They are effective in the work of the muscles.	-The most important concept in the work of muscles.
OXYGEN	-The most important gas necessary for the continuation of life. -Usage capacity can be improved with aerobic training. -If the usage capacity increases with training, it increases in endurance.	-Used for breathing. -O2 is the most important part of life. -We cannot live without oxygen.	
ATP	-Energy is provided from ATP. -It consists of three phosphates and one adenosine. -It is ready energy in anaerobic training.	-There is energy -ATP is the energy in the body.	
MITOCHONDRY	-Organelle that provides energy production in the cell. -Muscle and nerve cells contain large amounts of mitochondria. -Performs ATP synthesis with oxygen. -The place where energy is created after the nutrients become suitable for burning.	-It is the powerhouse of the cell. -It is the energy source in the cell. -Cell building block.	

Table 4 (continued).

Key Concepts	Sentence Examples Containing Scientific Information	Examples of Sentences Containing Unscientific or Superficial Information	Sentence Examples Containing Misconceptions
ACTIN	-It is the protein found in the muscle, together with myosin, it allows the muscle to relax and contract. -It provides energy generation with the sliding filament theory by pulling with myosin inside the cell. -Thin threads that provide contraction. -It allows the muscle to contract and relax.	-Muscle Protein -Works with a tie.	-Helps in muscle production.
MYOSİN	-Thick threads that interact with actin filaments in muscle cells and provide contraction -It provides the movement of cells. -They work with neural stimulation.	-It is effective in contraction. -Works with actin. -It's muscle protein.	-They are thick threads that provide contraction.
HYPERTROPHY	-It is the increase in volume, not in number, of the tissues that make up the muscles. -There should be a continuous increase in muscle growth studies. -Increase in muscle volume with increased capillary.	-He develops with his training. -The body must be active in muscle growth. -Muscle growth.	-Increase of muscle cells.
ATROPHY	-The shrinkage of a tissue, cell or a cell for some reason. -The loss of muscle volume when training is stopped. -Reduction in muscle after aging.	-Muscle loss -Muscle shrinkage -Muscle change	-Muscle growth
ENGINE UNIT	-Composed of fibers equipped by axons. -Works to perform the contraction of a single muscle. -Composed of striated muscle fibers and neurons. -Stimulation of muscle fibers by a single neuron.	-Transmission center -Arousal occurs.	
SARCOPLASMA	-The fluid that fills the myofibrils in the muscle cell. -Muscle cytoplasm	-Muscle fluid	

occur at the expected level [25]. Another researcher examined the persistence of 9th grade students' environmental cognitive structures and conceptual development with WAT, after applying the first test, he applied the second test 1 year later and showed that the students' knowledge after 1 year was based on their experiences in daily life rather than scientific statements, and their cognitive structures about concepts were insufficient [19]. As a result of the WAT conducted after the lectures in the field of genetics with 280 biology students at Glasgow University, it was revealed that although the students produced many answers to the given key concepts, they could not see these concepts as an intertwined and related network [16]. In the WAT research on the circulatory system on pre-service science teachers; It was determined that although pre-service teachers had studied human anatomy and physiology, they could not associate lymph circulation with any concept and their knowledge about this concept

was insufficient [33]. The researcher trying to determine the cognitive structure and conceptual change process of secondary school students on the Solar system and space using the pre- and post-test WAT. It has been revealed that students' conceptual changes improved positively in the post-test compared to the pre-test and their misconceptions decreased [22]. A different researcher, on the other hand, stated that the students showed a positive development in terms of conceptual change in the post-test as a result of the WAT, in which he applied the pre-test and post-test on the subject of Health in the primary school Turkish lesson. However, in the same study, it was determined that the body key concept emerged in a disconnected and unrelated way in the cognitive structure of students as a result of both tests [40].

Conclusion

It was concluded that the WAT results applied before and after the training knowledge lesson of the students were different from each other and their cognitive structures changed. However, students could not reach sufficient levels in learning meaningful about the subject and correctly associating concepts. While there may be many reasons for this situation, the most important ones are such reasons as the inadequacy of the time allocated to the subject, the fact that the concepts are very abstract concepts that are not used much in daily life, the foreknowledge and misconceptions that have been obtained before, and the insufficient infrastructure of the students can be counted. We can recommend educators to use student-centered learning approaches more, to diversify teaching methods and techniques, and to benefit from learning experiences by doing and living in order to gain concepts related to the research subject. The results of this and other related studies show that WAT is an effective valuation technique in examining pre- and post-knowledge, diagnosing concept relationships, and identifying misconceptions and the change process. Therefore, we suggest that WATs, which are used in this study to collect academic data, should be used as a complementary measurement and evaluation tool for student groups at all levels.

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