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April 01, 2021
Prof. Dr. Aytekin ISMAN
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A GENERATIVE APPROACH IN DIGITAL ARCHITECTURE BASED ON TOPOLOGICAL DESIGN

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ABSTRACT
Thanks to the significant changes experienced in architecture at the end of the 20th century and the beginning of the 21st century, numerical algorithms and computational models entered the field of design and a new horizon opened for architects. This new world of architecture not only transformed the design process but also led to the discovery of new methods for design production. In contemporary architectural design, digital media has been increasingly used not as a representational tool for visualization, but as a generative tool for derivation and transformation of form. Approaches of computational and digital architectures to the design problem can be described as deductive and inductive. In the first, a transformation is applied to an object whose result is known. In the second, it is possible to reach the unknown from the data in order to obtain a certain result. Digital modeling software offers a rich repertoire of transformations that a designer can use to further explore the formal potential of an already designed geometry. The end product is topologically the same as the form before deformation. The concept of topology has an important potential for the formation and transformation of form in architecture. The aim of this study is making conceptual analysis of topological design included in the recent design parameters and discussing its place in contemporary and future architecture through architectural examples. In this context, firstly a literature study was conducted, the examples of topological design processes reflected in today's architectural discipline were examined and the results were evaluated.
Keywords: Computational Design, Digital Architecture, Parametric Design, Topological Design, Productive Approach

1. Introduction

According to Merriam-Webster and Oxford English Dictionary, topology, which is defined as a branch of geometry that deals with the study of spatial relations and the properties of geometric shapes that remain unchanged under elastic deformations such as flexion or bending, is derived from the Greek words τόπος (place) and λόγος (science, knowledge). 'Topology', in other words, 'tire geometry' is the geometry of non-angular shapes and deals with flexible forms; In this respect, it differs from Euclidean geometry, which deals with solid forms.

Geometry has always been directly related to architectural thinking styles through the problems of conceptualization, representation, construction and technology in architecture. With a historical view of these two disciplines, it is possible to perceive the direct effects of geometry on architectural creative concepts, formal features of architectural works, structural features, and building methods in architecture. Thus, architecture and geometry have a common history and their relationship predates the use of digital and computer technologies in architectural theory and design. However, the emergence of mathematical topology in contemporary architecture is linked to the increasing use of digital and computational tools in the design process. The topological design was defined by Kolarevic (2000b) as one of the computational and digital architecture methods.

Computational design gained its current conceptual meaning with the influence of the modernist thought and discoveries of the 1960s. With the introduction of the computer in design, calculation features have been started to use and some applications are called computational design. It was first used in areas such as artificial intelligence, cybernetics, industrial design, film and music industry (Akipek and İnceoğlu, 2017; Papamichael & Protzen, 1993; Simon, 1969; Wiener, 1948). CRAFT, an algorithm-based system that uses heuristic methods to optimize spatial location models for physical facilities such as production facilities, was the first application (Armor & Buffa, 1963, 1963).

Ivan Sutherland's thoughts on design diversity, constraints and parametric examples, influenced the transition to computational design in architecture. Sutherland also introduced the Sketchpad program, which is the ancestor of CAD (computer-aided design) tools, in 1963 (Sutherland, 1963; Ahlquist & Menges, 2011).
The first attempts to combine architecture and computational design were made in the 1970s. In the 1980s, computational design became known and available in architecture thanks to the commercialization of CAD (Computer-Aided Design) and BIM (Building Information Modeling) supported design tools (Koutamanis, 2005).

Since the automation of repetitive tasks increased the productivity of architects throughout the 1990s, the popularity of CAD software has increased considerably. In the 2000s, these techniques applied in the architectural design exceeded the automation of draft tasks (Terzidis, 2004). Recently emerging design approaches; have integrated different computation-based techniques such as building simulations, evolutionary optimization and new production methods with the design process (Oxman, 2017). The popularization adventure of computational design over time has caused a transformation in traditional design processes. The old design concept was based on manual drafting in the design process. Today's computational design concept has challenged and renewed old architectural design acceptances and professional practices (Rocker, 2006).

The expansion and development of digital tools and the increasing usage of computational design methods have taken place simultaneously. Although the use of digital tools such as computer programs is referred to as digital design and the use of computation to improve design is referred to as computational design in general, these two concepts have been intertwined in the process. It is not possible to evaluate the two methods separately.

There are two perspectives on computational design. While some authors consider it as an approach based on the use of digital tools such as CAD programs to develop design solutions (Alfaris, 2009; Knight & Stiny, 2015; Stiny & March 1981), others think that it is an application that uses all the capabilities of the computer in the design process. Computational design is defined as a holistic process that takes the final result by using digital tools that benefit of the computer's computational capabilities, besides that using the computer as electronic drawing boards (Albayrak, 2011; Cagan et al., 2005; Humppi, 2015; Oxman, 2017; Peters, 2013. Terzidis, 2006).

Digital architecture and design have been seen by some as an approach where tools such as computer-aided design programs are used, and decisions are made through three-dimensional models, not sketches in the design process (Turan, 2009; Marx, 2000). The possibilities provided by digital methods have been defined by some as computational, productive processes used in formation and transformation, beyond being presentation tools (Kolarevic, 2003).

Computational and digital architectures have two types of approaches to design problems: from specific to general or from general to specific. In the approach from general to specific, the transformation is made on a known object. In the other method, an unknown result is tried to be reached by using the data (Chokhachian, 2014). With digital modeling tools, potential forms that already designed geometries can be transformed are investigated.
Deformed forms and end products are topologically identical. The concept of topology offers an important potential in architectural formation and transformation.

Today, digital architecture has more than the representatively used possibilities for visualization and is used effectively not only in the architectural design process but also in the architectural production process. The predictable relationships between design and representations have been abandoned in favor of computationally generated complexities. Consistent, continuous and dynamic designs have replaced the static norms of traditional processes. Complex curvilinear geometries have been produced with the same ease as Euclidean geometries of planar shapes and cylindrical, spherical or conical forms. The aim of this study is to make a conceptual analysis of topological design that is among the new design parameters formed recently and to discuss its place in architecture by examining architectural examples.

2. Topological Design and Applications in Architecture

According to its mathematical definition, Topology is a branch of science that studies geometric forms that are not affected by changes in size and shape and remain unchanged after elastic deformations such as flexing and bending. In order to understand the topology simply, a rubber sheet example is given. Accordingly, the surface on which the geometric object is located is considered an elastic sheet. It is possible to extend, stretch or loosen this sheet as much as desired, as long as it is not folded and torn. During this process, each new shape that the geometric object will be transformed is a topologically transformed state of the other (Yaşayan, 2001).

This transformation, which is made by pulling and expanding or crushing and shrinking without tearing and cutting, is called "homeomorphism". A circle and an ellipse or a square and a rectangle can be considered topologically equivalent because both the circle and the square can be deformed by stretching them to an ellipse or rectangle. A square and a rectangle have the same number of sides and the same number of corners and therefore they are topologically identical or 'homeomorphic' (figure 1). This quality of homeomorphism is particularly interesting because it focuses on the relational structure of an object, not the geometry, the same topological structure can manifest geometrically in an infinite number of forms. In topological transformations, geometric shapes are transformed completely independent of their metric properties (Yomralıoğlu, 2000).
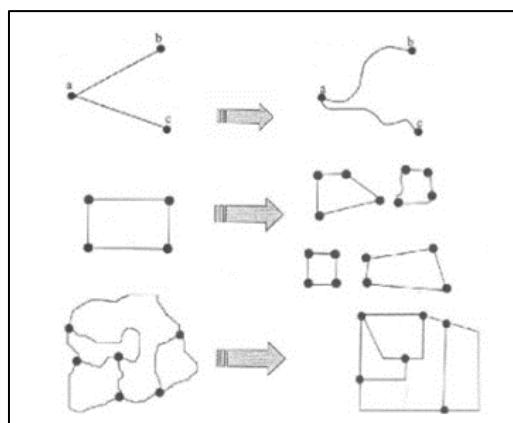
Figure 1. Topologically equivalent shapes (Karaş and Batuk, 2005)

'Topological transformations' affect the relational structure and thus the forms that emerge. For example, a rectangle can be transformed into a triangle by deleting one of its corners in a single topological operation. In all topological transformations, closed shapes retain their closed properties. The changes of the shapes do not lose their topological properties. As a simple example, we can show that a square is topologically equivalent shapes to a circle (Figure 2). The properties protected here; the feature of being closed is that the points on the shapes continue to be sequences and shapes that do not cut themselves. The changing feature is the lengths.
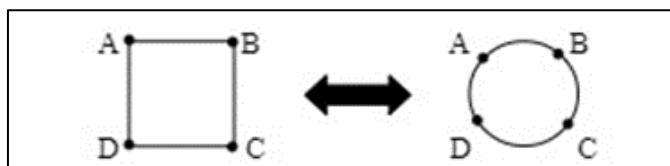
Figure 2. Topological transformation of square and circle (Karaş and Batuk, 2005)

A typical example of this is that the outer surface of a coffee mug with a handle is the same in some sense as the outer surface of a torus (bagel form). If the coffee mug was made of wet clay, it could easily bend, rub and flat the remaining part without changing the handle and the whole cup could be put into a torus form (Figure 3) (Tarım, 2006).
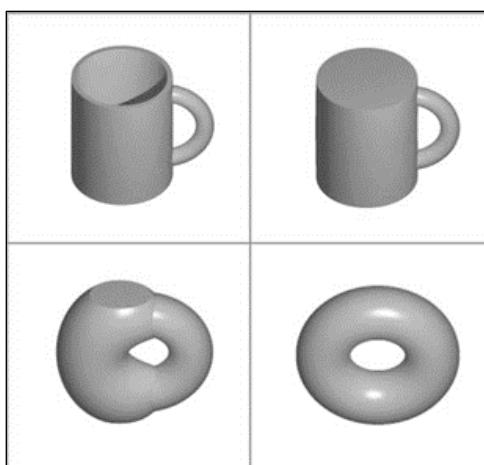
Figure 3. Mug-torus transformation as a topological shape

One of the first shapes that comes to mind when "topological form" is mentioned is the Möbius Strip. Möbius strip is the surface obtained by bending one end of a geometrically long strip 180 degrees and joining it with the other end. It was first described in 1861 by Johann Benedict Listing. A normal strip has two sides, while a Möbius strip has only one side In other words when starting to move from a point on the Möbius strip, the whole area is scanned, and the same point is returned (Figure 4).
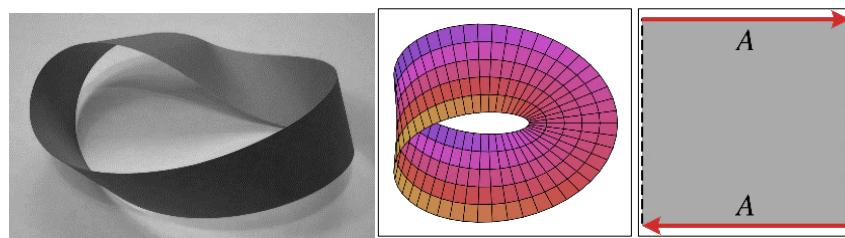
Figure 4. Möbius Strip

There are two different uses of topology in architecture: the topological understanding adopted by some philosophical and theoretical writings; topological optimization approaches that are seen with the emergence of topological tools used in drawings and models. In addition to the usage of digital techniques in contemporary architectural designs, the views of philosophers and theorists such as Gottfried Wilhelm Leibniz and Gilles Deleuze have also played an important role. The view of philosophical creativity, which supports the creation of new concepts through experimental thinking, instead of describing known phenomena, formed the basis of Deleuze's theory. Thanks to its close relationship with experimental thought and scientific knowledge, this thought has established a connection with topology and mathematics and has acquired a spatial quality. The contrasts such as small-large, discontinuity-continuity, metric-topology and fold-roughness have been explained. Deleuze not only made conceptual interpretations about topology but also made this concept accessible to everyone. He used spatial properties to interpret the problems in social and individual relations. In this respect, it has been accepted by architects who oppose the linear causality of design in contemporary works in architecture (Lojanica and Dragisic, 2018).

In his essay on "Architectural Curvilinear", Greg Lynn has presented examples of new design approaches that break away from deconstruction's "conflict and contradiction logic" to develop a "more fluid connection logic". This new "connection fluidity" has introduced the concept of "folding", a design strategy that uses the "rubber plate" geometry of volumes, curves and surfaces separated from the Euclidean geometry represented in Cartesian space and the concept of topological form. The "folding" as defined by Deleuze has introduced a post-structuralist concept of space "consisting of platforms, cracks, folds, fillings, surfaces and depths that completely displace our spatial experience. "Folding" has become a new and distinctive "formless architecture" that questions the current concept of built-in space, its aesthetics and usefulness (Lynn,1993).

Thanks to the great transformations in architecture at the end of the 20th century and the beginning of the 21st century, changes can be made in drawings in a faster and easier way with the use of digital technology. Due to different computer software, the design and analysis process can be carried out together. Architectural design and Topology which is a branch of mathematics and, have been combined in various ways, with computer systems, CAD software and compatible plug-ins that can produce a large number of alternative designs.

The topological approach or deformation in architecture is the architectural trend that carries the traces of deconstructivism, is based on contemporary computer animation techniques and gives flexibility and plasticity to the architectural form. Reproducing the dynamic derivatives of the form depending on computer technologies is the main activity of the topological approach in architecture. Topological forms with complex geometries used in architectural design offer architects a more controlled process for the realization of the design. Because the computer software used in the construction of a structure with complex forms is based on a formal and algorithmic structure, it also brings with "process control". The transformation of the design into production depends on data transfers in this process (Tarım, 2006). The forms used in architecture in traditional design consist of simple objects such as cylinders, pyramids and spheres in Euclidean geometry. However, in recent years, architects have begun to focus on designs in more complex forms. Architectural forms within the scope of topology do not belong to Euclidean geometry (sphere, pyramid, cylinder ...), but they belong to a new understanding of mathematic such as topology and vector geometry used in the digital world (Kolarevic, 2003).

The place of topology in the design process begins in the early stages of the project and continues until the emergence of the final product. Topological optimization in architectural design is a series of methods used to select and optimize the final product in the final stages of the digital process. The topological design optimization approach is used together with computer-aided design systems for determining the optimal structural model that can be used for post-design operations (Figure 5). The basic logic of topological optimization, which has been widely used in recent years as a structural optimization method, is based on the principle of discharging material from certain areas as a way to increase the strength of the part to be optimized without any change of outer dimensions.   The aim of topological optimization is to find the best material distribution that maximizes stiffness

or natural frequency. The Homogenization method used for the solution of topological optimization problems was developed by Bendsoe and Kikuchi in 1988. The density method that is another method commonly used for the solution of topological optimization problems is R.J. Yang and C.H. It was developed by Cuhang in 1993 (Öztürk and Kaya 2000).
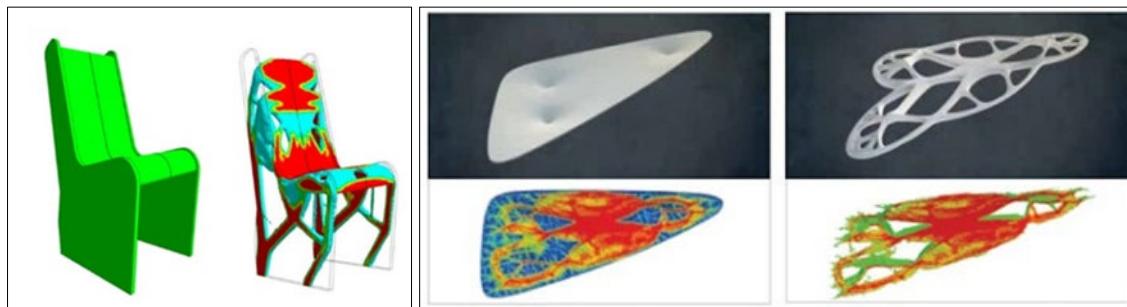
Figure 5. Examples of topological optimization

3. Case Study: Examples of Topological Architecture
3.1. Heydar Aliyev Center

Heydar Aliyev Cultural Center that built by Zaha Hadid Architects in Baku, Azerbaijan is an example of topological design with its shell structure (Figure 6). The fluid form of the building consists of a single *topologically deformed* surface where the floor transforms into a wall and then a ceiling (Figure 7). The design of the shell was inspired by the rise of the Caspian Sea in Azerbaijani mythology (Figure 8).
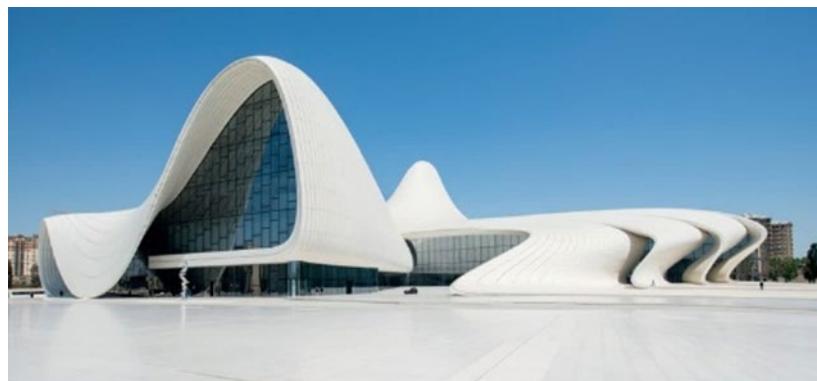
Figure 6. Heydar Aliyev Center

Figure 7. Heydar Aliyev Center's topological deformations
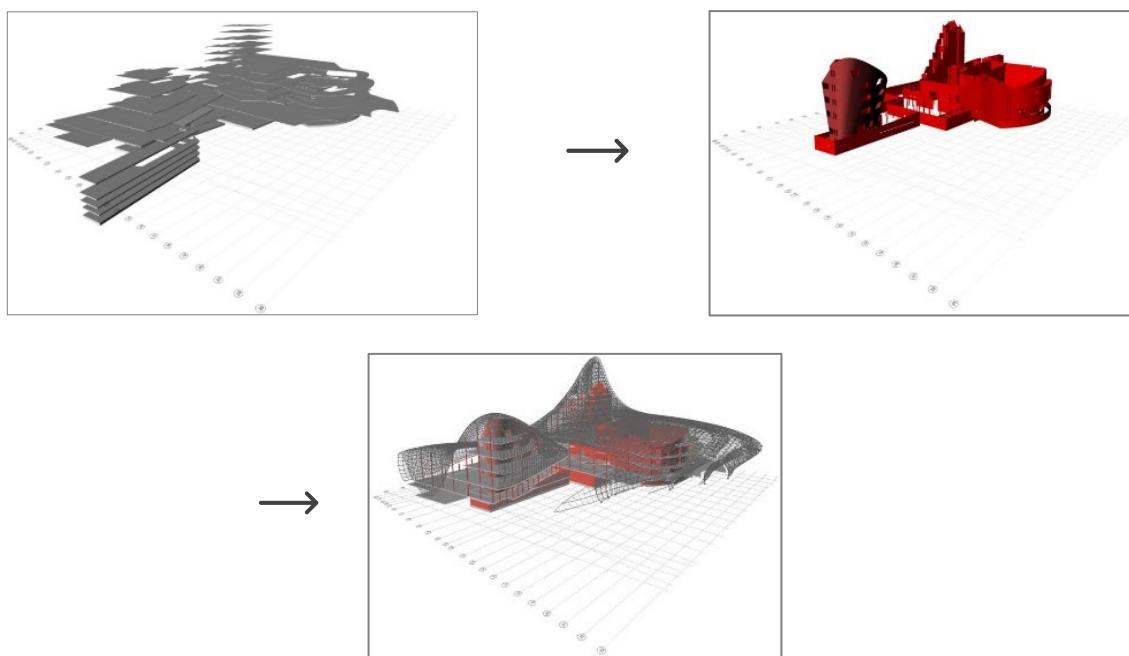
Figure 8. Heydar Aliyev Center's structural development diagram

3.2. Mobius House

The starting point of the building designed by Stephen Peralla and Rebecca Carpenter is the Mobius strip that is a topological form (figure 9). Topological architecture is used in both the organizing of the program and the form of the building. The building near Amsterdam describes a topological cycle with its curved shape and intersections made at different angles in nature (Figure 10). After the Mobius strip is made three-dimensional, the starting point for the building has been obtained.

Figure 9. Mobius House
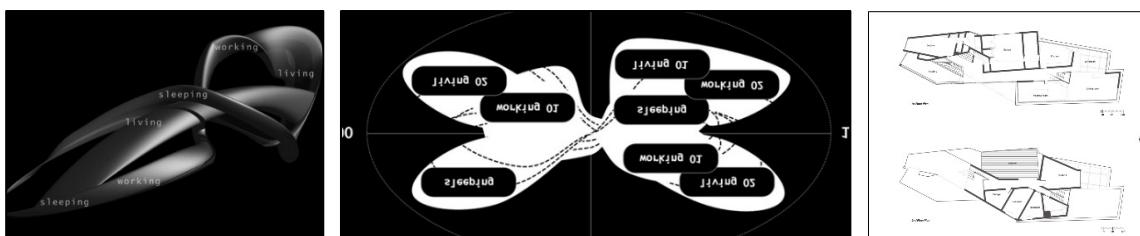
Figure 10. Mobius House concept diagram and plan diagram

This building's program is combined in a loop without using any connection points just like the Mobius strip (Figure 11). The floor plan, circulation and structure are integrated.
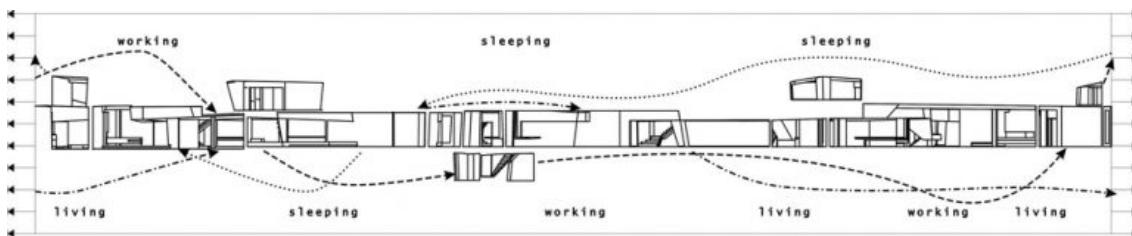
Figure 11. Loop diagram

3.3. London Aquatics Centre

The starting point of the geometry of the London Water Sports Center obtained by the topological method is the fluid form of the water in motion. It features spacious venues that open to the view of London's Olympic Park (figure 12).

Figure 12. Views of London Aquatics Center

The top cover, which has a remarkable design and provides the structure with its unique character, is a *topologically deformed* surface element (Figure 13). Covering a large area, this wavy top cover not only covers the halls where the pools are located but also functions as an eave over the main entrance coming from the Stratford City Bridge.
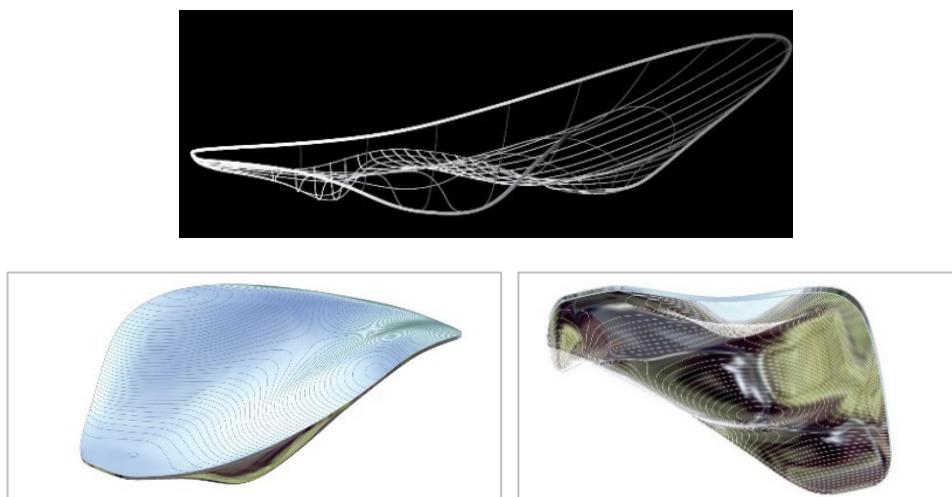
Figure 13. Concept and design of the London Aquatics Center's shell

3.4. MoPOP (Museum of Pop Culture)

The starting point of the Experimental Music House's *topologically deformed* form is the crumpled papers thrown into the trash of a guitar store near Gehry's office in Santa Monica. Its interior parts are divided by curvilinear walls called 'Snakewall' (Figure 14). Although approximately 100 physical models were made for the structure, three-dimensional modeling techniques and computer software were used to develop the final product.

Figure 14. Views of MoPOP (Museum of Pop Culture)

3.5. Harbin Grand Theatre

The Harbin Opera House, built by the MAD group, which won the international competition within the scope of Harbin Cultural Island in 2010, has been integrated with the wetlands of Harbin. It was designed with the desolation and cold climate of the city in the north in mind. The building is in harmony with its surroundings and topography with its sculptural and monolithic appearance. According to the MAD group that designed the building, Harbin Opera House is a transmission of local identity, art and culture. With its form created by *topological deformations*, it gives the feeling of a natural formation formed by water and wind in the wetland where it is located (Figure 15).

Figure 15. Views of Harbin Grand Theatre

3.6. Walt Disney Concert Hall

Walt Disney Concert Hall, which permanently hosts the Los Angeles Philharmonic Orchestra, is among the most important concert halls in the world with its iconic architecture and near-perfect acoustic performance. The building which has a *topologically formed* curved metal shell identified with Frank Gehry is one of Gehry's best-known works (Figure 16).
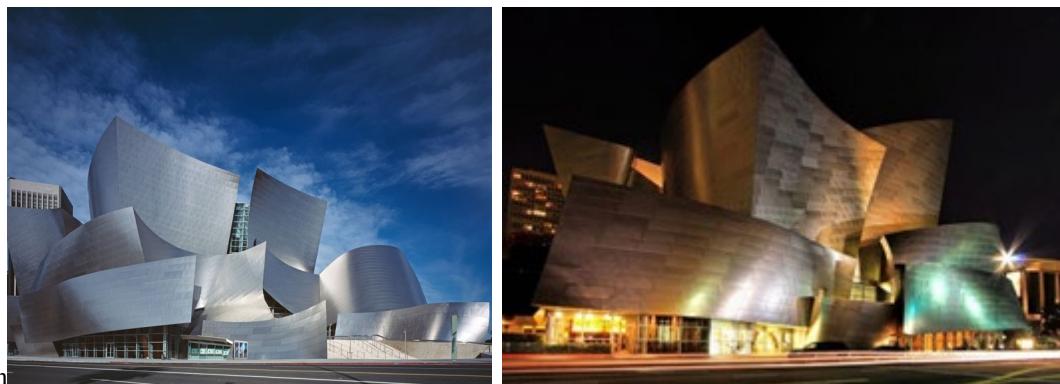
Figure 16. Views of Walt Disney Concert Hall

The facade of the Walt Disney Concert Hall, which is vibrant, wavy and formed by the combination of different angles, based on the *topological deformation* of the surfaces, reflects the musical mobility. As in most of his designs, Gehry achieved the final shape of WDCH by drawing sketches and making three-dimensional paper models. The unusual curved shape of the building has been produced with a structure fiction developed specifically for this extraordinary design.

3.7. The Hotel Marques De Riscal

Gehry, who uses curved metal installations created with *topological deformation* with titanium and steel materials on the exterior of this hotel, which was built in place of a 150-year-old stone winery, wants to make the hotel more visible with the reflections of the sun and moonlight (Figure 17).

Figure 17. Views of the Hotel Marques De Riscal

3.8. The Fisher Center for the Performing Arts

The Fisher Performing Arts Center is the latest building to be added to the Bard College campus. The building, which has a curved façade consisting of a *topologically deforme*d surface designed by Gehry, is located at the foot of the Catskill Mountains (Figure 18).

Figure 18. Views of the Fisher Center for the Performing Arts

The Fisher Center for the Performing Arts demonstrates Bard College's commitment to the performing arts as an educational and cultural necessity. The center's interesting programs and facilities provide an exceptional environment for creativity to be realized, learned and experienced. The center is named after Richard B. Fisher, former chairman of Bard's Board of Trustees.

3.9. Lou Ruvo Center for Brain Health

Designed as a building that people want to visit, remember, talk about and enjoy, the first goal of Lou Ruvo Brain Health Center is to preserve memory, and the second is to create memories. In line with these objectives, the Center designed by Frank Gehry by *topologically bending and transforming* consists of two separate buildings connected by a courtyard (Figure 19).

Figure 19. Lou Ruvo Center for Brain Health

The first building of the facility is a fully equipped service building aimed at preserving memory with both administrative offices and health research and clinical operations. The second building is the Life Activity Center building, which is reached by passing through a covered passage made of curved stainless-steel forms and illuminated by natural light from 199 windows. The building is designed as a truly unique event space to create memories with its design (Figure 20).

Figure 20. Entrance facade of Lou Ruvo Center for Brain Health

3.10. Guggenheim Museum Bilbao

Guggenheim Museum Bilbao is a modern art museum located in the city of Bilbao, in the Basque Country region of Spain. The museum situated on an area of 11,000 square meters is one of the five museums of the Solomon R. Guggenheim Foundation. The structure, dominated by curvilinear forms formed *by topological deformation*, was designed by Frank Gehry (Figure 21).

Figure 21. Views of Guggenheim Museum, Bilbao

4. Conclusions

With the industrial revolution, increase in the use of iron and steel, developments such as mechanization and mass production have affected the structure of society and the architectural discipline that interacts with it. The architecture was introduced to the technology of the age, constructing large-span structures became easier, new materials and new structural systems were started to be used.

After the industrial revolution, which is accepted as the first milestone in architectural design, the second milestone was experienced with the spread of computer technology and the introduction of computers into architectural design. The changes that started with the introduction of the computer into the design at the end of the 20th century and the beginning of the 21st century evolved from the two-dimensional designs of Sketchpad to three-dimensional designs in the 1960s. Thanks to the artificial intelligence studies carried out by Alan Turing in the 1980s, changes have continued with the merging of the concept of three-dimensional space, which is today's design concept, with computer technology.

In the traditional design process, the visual thinking method, which consists of putting the thoughts in the mind on the paper through representations, has been replaced by digital continuity with the introduction of computers into the design. Digital continuity refers to the intertwining of processes separated as design-representation-application in the traditional process in the digital design process.

In computer-aided design the design information transferred from the file to the factory with CAD / CAM technology has made architectural designs manufacturable. In addition, computers have brought the ease of producing curvilinear shapes with complex geometries, which are difficult to develop in the traditional representation environment, to architecture. Unlike the traditional design process based on representation and imagery, computers carry out operations based on numerical parameters and algorithmically defined relationships. After that, studies in the design field have progressed from making a form to finding form. As a result of all these developments, a new language has begun to emerge in architecture. Architecture with complex geometries, dominated by a flexible space understanding with curvilinear and fluid lines, has begun to be adopted as a contemporary architectural language.

The concept of topology in architectural design has made the dynamism and flexibility in the new spatial concept identifiable with subforms such as blob, bleb, and fold. As a result of this study, it was concluded that the concept of topology cannot be reconciled only with curvilinear forms, it is a phenomenon that includes concrete and abstract data that expresses the whole design knowledge rather than the formal meaning.

Topological optimization in architectural design is the last step to optimize the product obtained at the end of the digital design process in line with criteria such as function, cost, aesthetics, durability, acoustic value, and light. The concept of topology emerged as a result of the introduction of computer-aided design into architecture, and its effects on architectural design have been revealed with examples.

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A QUANTITATIVE ASSESSMENT METHOD RECOMMENDED FOR THE STATE UNIVERSITIES IN TURKEY

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ABSTRACT
The university ranking systems have been utilized for academic performance of higher education system in the World since beginning of 2000's years. These systems, which considered the common parameters, have quickly followed with their own hierarchical measures by higher education organizations. However, these ranking systems never consider   country's special conditions. This paper mentions the main principles of a new system for state universities performance in Turkey. The quantitative assessment method depends to six separate parameters such as number of publications and projects, teaching quality, teaching income, teaching structure, the index for entrepreneurial and innovative university and student satisfaction. The technique provides data for well-balanced and justice decision for the national state universitiesthroughout the country. Summation of all numerical values resulted from six parameters represents total score for the related university. The total score obtained for an university also gives its place in the ranking system of higher education in the country. It is possible the central budget to be shared to all state universities in Turkey by means of this method.
Keywords: Higher Education, Performance Assessment, University

Introduction
According to the report of OECD (2013), universities in developed countries, rather than the institutions that carry out classical education and training services, mostly transform to the research organizations integrated with the industry and producing information. Universities in relevant countries are supported by the governments in order to transform and accelerate transformation, which is considered as a strategic change. It should be noted that state support for North American universities is largely towards to research and development projects (Meyerson, 1988).

Turkey is one of the countries where education sector is very large in the world. With end of 2018, the number of faculty (academic staff) is 158 098 in Turkish Universities.   The full professors and associate professors are about 33 and 39 percent of total members of faculty, respectively.   In Turkish Universities more than 7.5 million students are studying at different levels as end of year 2019.   The number of students studying in two-years programs is 2 768 757 while it rises up to 4 241 841 for four-years programs.   The number of students in graduate study is 549 773. The seventeen percent of graduate students is studying in doctoral degree program.   The graduate study is only about seven percent of total system in Turkey.

In the context of this study, an assessment technique, which depends to six separate parameters, was recommended. The parameters of this specific assessment technique are teaching income, teaching structure, teaching quality, number of publications and projects, the index for entrepreneurial and innovative university, and student satisfaction. The suggested technique provides data for well-balanced and justice decision in sharing the financial resources allocated by the central government in Turkey. Summation of scores belonging to each parameter gives total score for the related university to obtain its place in the ranking system of higher education system in Turkey. In addition to this, the technique also provides a ranking for each parameter (Tosun, 2015). It has been developed for only state universities in Turkey.

Literature survey for Performance Assessment and Metodology
In general, performance appraisal can be classified into two groups as traditional and modern methods (Tosun, 2019). Traditional methods are older methods for performance appraisal which concentrated only on the past performance. There are the topical traditional methods used in the past: (1) ranking method; (2) graphical rating scales; (3) critical incident method; and (4) narrative essay method. Modern methods were introduced to improve the conventional methods. They consider the shortcomings of the old methods, such as biasness and subjectivity. The typical modern methods are generally categorized into six groups: (1) management by objectives (MBO); (2) behaviorally anchored rating scales (BARS); (3) humans resource accounting (HRA); (4) assessment center; (5) 360 degree; and (6) 720 degree. In MBO, which includes three main processes: object formulation, execution process, and performance feedback, the performance is graded against the achievement of the objectives specified by the management. It generally consists of several components (Tosun, 2019).

In addition to traditional and modern methods mentioned above, there are some various fuzzy hybrid techniques to execute performance appraisal for individuals or organizations. The author has studied on the performance of higher education institutes and suggested a financial model for sharing the central budget allocated by the

Government and has so many national publications on this issue (Tosun, 2004; 2006; 2015; 2016 and 2019).   This paper summarizes the main principles of the specific method introduced for evaluating the universities in Turkey and introduces the result of studies, which was executed on performance of universities established at the different periods. The model is based on methods of ranking and graphical rating scales. It includes the studies, which were done along 12 years.

Currently, there are some ranking systems for the world universities based on academic performances, which determined by quality and quantity of scholarly publications. These methods, which have been implemented since the first half of 2000's years, adapted to an important criterion for questioning position of universities with time. Times and QS in United Kingdom, ARWU-Jiao Tong in China, Leiden in Nederland, and SCImago in Spain are some of the evaluation systems that are internationally renowned. These systems are based on reliable sources, such as Scopus, Web of Science, and Google Scholar. In Turkey, University Ranking by Academic Performance (URAP) ranking system developed by Middle East Technical University globally measures universities according to academic performance. In the context of this study, an assessment technique, which depends to six separate parameters, was recommended.

The model Recommend for Performance Assesement of State Universities
In the model, twenty-seven parameters in six areas were taken into account for performance assessment of the state universities in Turkey. These parameters are given in Table 1. The parameters of this specific assessment technique are explained below:

Teaching Income- The state universities in Turkey provide a significant portion of their income from the central government budget. The university budget on the basis of economic classification in the chart is categorized into five main titles as personnel expenses, social security state premiums, goods and service purchasing expenses, current transfers, and capital expenditures. Total of these five items constitute the university's portion from the central government budget for one year. Teaching income is considered as a separate parameter in the model and the Teaching Income Score (TIS) is calculated.

Teaching Structure- The teaching structure in the modern university system is categorized into undergraduate and graduate levels. Undergraduate level includes two-year and four-year programs. This parameter means at which university intensifies degree of level or levels. For this purpose, four different evaluation criteria are defined and the Teaching Structure Score (TSS) is calculated taking into account the influence factor values of each evaluation criteria (Tosun, 2015). The great value of Teaching Structure Score means the university in where graduate education is major. Otherwise, undergraduate level including two-year programs is predominant.

Teaching Quality-The teaching quality in higher education institutions in developed countries is generally assessed by the number of students per faculty member and per research assistant. In this study, six different criteria are defined in order to determine the quality of teaching of universities and the Academic Quality Score (AQS) is calculated for each university based on the relevant criteria and taking into consideration the influence factors (Tosun, 2004; 2015). Table 1 introduces the criteria considered for teaching quality with others.

Publication Efficiency- Publication data used in this study were collected on the basis of the whole document using "Thomson Reuters—Web of Science Database".]For this study, scientific efficiency was taken into account as a basic parameter, which mainly depends to unit number of publication and citation, which are scanned by international indexes (Sciences Citation Index-SCI, Social Sciences Citation Index –SSCI and Arts & Humanities Citation Index-AHCI) and then the Publication Efficiency Score (PES) is determined (Tosun, 2004; 2015).

Project Yield- Universities in developed countries produce projects in different scopes and seek support for these projects to use facilities central and local governments, public and private sector institutions and gain the culture on research and development, innovation and entrepreneurship. Within the scope of this study, project numbers and budgets supported by the Scientific and Technological Research Council of Turkey (TUBITAK) and the General Directorate of Science and Technology of the Ministry of Science, Industry and Technology (SAN-TEZ) with serious evaluation criteria were evaluated and then calculated the Project Yield Score (PYS) based on the impact factor value of each evaluation criteria in the field of project yield (Table 1).

Table 1. The parameters considered in the performance assessment method for state universities in Turkey

#	Area	Ratio to total score (%)	Area Score	Parameters	Impact factor of parameter
1	**Teaching Income**	10	100	Ratio b/t personnel expenses and total number of students	0,1
				Ratio b/t total budget and total number of students	0,6
				Ratio between capital expenditures and total budget	0,1
				Ratio between self-income and total number of students	0,2
2	**Teaching Structure**	10	100	Ratio b/t numbers of students on PhD and MS Degree	0,3
				Ratio b/t numbers of graduate and undergraduate students	0,3
				Ratio b/t numbers of pre-undergraduate and undergraduate students	0,1
				Ratio b/t undergraduate and total (excluding graduate) students	0,3
3	**Teaching Quality**	20	200	Ratio b/t numbers of total student and faculty *	0,4
				Ratio b/t numbers of total students and assistant faculty	0,4
				Ratio b/t research area and number of faculty	0,05
				Ratio b/t education area and total number of students	0,05
				Ratio b/t total area and total numbers of faculty and staff	0,05
				Ratio b/t social activity area and total students	0,05
4	**Publication Efficiency**	25	250	Ratio b/t total number of publications and faculty	0,2
				Ratio b/t total number of citiations and faculty	0,2
				Ratio b/t number of citiations and publicaitons	0,2
				Ratio b/t total number of publications and age of university	0,2
				Ratio b/t total number of citiations and age of university	0,2
5	**Project Yield**	25	250	Ratio b/t total number of TUBITAK projects and faculty*	0,25
				Ratio b/t total number of SAN-TEZ projects and faculty*	0,25
				Ratio b/t total amount of projects and total number of projects	0,1
				Ratio b/t total number of patent and faculty	0,2
				Ratio b/t total number of utility models and and faculty	0,2
6	**Entrepreneur-Innovation and Student Satisfaction**	10	100	Entrepreneur-Innovation and Preference Score	0,6
				Free quata for two-years programs	0,2
				Free quata for two-years program	0,2
Total		100	1000	Totally 27 parameters	1.0 for each area

(*) including only full professors, associate professors and assistant professors

Entrepreneur-Innovation and Student Satisfaction- An index on entrepreneur and innovative university has been started in 2011, considering 23 indicators in the leadership of TUBITAK. This index which was depended on the basis of universities' scientific and technological research competence, intellectual property activity, cooperation and interaction activity, economic contribution, and commercialization potential is calculated for each university and the scores of the universities in the first 50 are announced. For this study, a new parameter is defined as based on the above-mentioned index and student satisfaction, and then the score of parameter on Entrepreneur-Innovation and Preference Score (EIPS) is calculated.

Summation of scores belonging to each parameter gives total score for the related university to obtain its place in the ranking system of higher education system in Turkey (Equation 1). The evaluation was based on a total score of 1,000 and the score for each parameter is given below.

$$TPS = TIS + TSS + AQS + PES + PYS + EIPS \qquad (1)$$

in which
TPS = Total Performance Score (1,000 points)
TIS = Teaching Income Score (100 points)
TSS = Teaching Structure Score (100 points)
AQS = Academic Quality Score (200 points)
PES = Publication Efficiency Score (250 points)
PYS = Project Yield Score (250 points)
EIPS = Entrepreneur-Innovation and Preference Score (100 points)

In addition to this, the technique also ranks state universities for each parameter (Tosun, 2015). The technique provides data for well-balanced and justice decision for universities in Turkey. It has been developed for only the state universities throughout country.

Discussions

The expansion of the higher education in Turkey has been remarkable between 2002 and 2018. As of the end of 2019, there are 209 universities in the country in total. There are 131 state universities (including 11 technical universities, 2 universities of Fine Arts and 1 Institute of high technology, as well as the Police Academy and the University of National Defense) and 78 foundation universities. Apart from universities, there are 5 vocational schools. Rapid development in this direction has led to problems in the higher education system in terms of qualifications. All universities across the country (including the foundation) must undergo a serious performance assessment every year, universities must be ranked and declared. This, in turn, will only be possible with a software suitable for the country. Because Turkey has its own conditions. A significant part of the budgets of public universities come from the Central Government Budget, it is not clear what the foundation universities spend for academic activities and researches directly and indirectly, and the reliability of known data is also questioned. All information in the higher education system must be safe and reliable. These principles should be contained in the reformed form of higher education legislation.

Currently, the number of students in the higher education system in thecountry has reached 8.0 million. In fact, this definition is incomplete. the number of students in the university system will decrease a lot, when 2-yearsprograms of vocational high schools are excluded from the system, and the system will relax and the possibility of evaluation on a more realistic basis will arise. A university with a school in each district in the province, in which it is located, cannot compete in a competitive environment with a university that does not have a 2-year program located in metropolitan areas. Therefore, the software utilized for performance evaluation should have the capability to respond to such changes in the system.

Today, there are no incentive measures for universities to provide high performance. The software that measures performance of higher education system throughout the country should provide significant clues in determining the state budget of the universities and provide a financial model with the country's higher education system. Of course, legal regulations are necessary to realize these items for higher education system in Turkey.

Restrictions should be placed on the transfer of public property to foundation universities. We have to be fair in creating a competitive approach. Otherwise, the deficiencies that still exist in the system increase and a skewed development is achieved. The situation of Istanbul şehir University, which is being discussed today, is a very good example to explain this flaw.   The software must have the ability to estimate university properties at current value and their value added.

Conclusions

Currently the higher education institutes in Turkey are far from being homogeneous and productive. Most of them only have a functionality on education of young people, not on scientific research.   Universities should have an institutional characteristic that illuminates the environment and influences social life rather than being classical institutions that provide normal education and carry out public affairs. Therefore, the performance of all higher education institutions in Turkey should be measured, their allowances should be given depending on their performance, and they should be transformed into institutions that are more effective in the production and transfer of information. For this, the method suggested above can be used effectively.

In Turkey, there is a board that evaluates the performance of universities within the higher education system. This board tries to do its duty in good faith by staying within the existing system. However, radical transformation should be achieved in the higher education system. The performance of universities should be determined every year using the method suggested above and state appropriations should be allocated according to the performance of universities. For example, universities should receive one-third of their total budget from local authorities. Universities should receive these fees each year in return for projects to be prepared in specific subjects, such as earthquake, flood, urbanization, social tissue treatment, mental health rehabilitation, water, land and mines, as well as for the effective use of local natural resources.   It is clear that the issues mentioned above can be checked by a well-defined system on performance evaluation for the higher education system.

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A RESEARCH STUDY ON THE EXPANSION OF STATE UNIVERSITIES IN TURKEY

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ABSTRACT

The university is a field of science and education where knowledge is produced and transferred to the sectors, teaching is done and individuals are given a profession to use in their lives. For all of these studies, students, faculties and staffs are needed in a higher education institution.   However, in order for studies in the academic field to be carried out correctly, these members must be presented at the University with the appropriate rates. In recent years, the number of students in the universities of Turkey has increased without conforming to some qualification ratios. This study depends on the data of 2010 to 2014.   The number of total students range from 1 741 719 to 2 397 188 within this period.   In this paper, the number of students as university stakeholders are presented according to the university categories, and the effect of student numbers on education quality are evaluated on the basis of different levels of study (pre-undergraduate, undergraduate, graduate) in Turkey.   The study indicates that the rate of expansion to Turkish universities is quite high, when compared with those of the developed countries.

Keywords: Expansion of university, higher education, state university, university category

Introduction

In the historical process, there have been different periods of the higher education system in the world. In the Middle Ages, higher education, which began to form as a teacher-centered in the north of Europe and a student-centered in the South, gained a new dimension during the Umayyad State of Andalusia in Spain, and then in most major cities in Europe, universities began to form as similar situations today. At the beginning of the 19th century, universities began to change, and later, with the system called the "Humbolt model", research activities gained momentum, and departments were created in faculties with one branch of Science, and the basis of the academic chair was taken to the plan. While medieval universities adopted the path of defending truth, the Humbolt university model took on the task of exploring nature (Charle and Verger, 2005).

The Humboldt model has also influenced universities in the United States (USA). But with this effect, US universities have achieved a more efficient and effective university model, maintaining their original values. In particular, they managed to establish relations with all segments of society, not respecting the elitist understanding of the Humboldt model and opening it to the wider public. By building a large number of universities with large campuses and providing the necessary technical and social infrastructure equipment, significant distance has been taken in the goal of raising a strong society. In summary, after the Second World War, there was a serious expansion in US universities. Recently, in these universities, it is aimed to produce information by interdisciplinary methods, to train people with more entrepreneurial identity than scientists, and a professional management style is adopted with a global understanding.

In Turkey, it is known that the decision to establish a university in the Western sense was first taken in 1846 and the establishment of this institution, called "Darü'l Fünun", could only be realized in 1865. This institution, which was closed 15 years after its establishment, was reopened in 1900 under the name "Darü'l Fünun - i Osmani". This institution, consisting of schools of medicine, law, theology, literature, mathematics and science, was also attended by foreign scientists in the following years. In 1933, this university was closed and established a new higher education institution called "Istanbul University" by law No. 2252 . In 1944 Istanbul Technical University, in 1946 Ankara University and between 1956 and 1957 four new higher education institutions were established. Although new universities were gradually established in the following period, the number of higher education institutions rapidly increased after the second period of the 2000s, and a very serious expansion in the higher education system emerged. Currently, the system has 210 higher education institutions with more than 7.5 million students.

The author thinks that the expansion of higher education system in Turkey is a huge problem for education quality and research studies (Tosun, 2004, 2006, 2011, 2015, 2016, 2019a and 2019b).   There are so many internal publications in quality of higher education system of Turkey (Doğramacı, 2007; Gunay, 2011; Günay and Günay, 2011 and Çetinsaya, 2014). In this study, the initial phase of this period (between 2010 and 2014) in Turkish university system, which has experienced a very serious expansion process in recent years, is analyzed with numerical values and especially the problems caused by the increase in the number of students are addressed

Materials and Methods

In the university system of Turkey, the number of students mainly includes students at associate (pre-undergraduate) and undergraduate levels. In general, six years of medical education and five years of veterinary education are included in the statistics as undergraduate level. In recent years, the number of students has increased rapidly due to the return from elitist understanding in our higher education system to the understanding of massization (expansion) and even the internationalization of our universities. The assessment on this issue will be carried out in detail in the forthcoming section.

Tosun (2004, 2006 and 2015) introduced much data for the higher education system in Turkey. In this study, the number of students for four years (2010, 2011, 2012 and 2013) was evaluated in detail. In the study, the number of associate, bachelor, master and doctoral students for each university was considered separately. These values were taken from the YÖK information system. But since the number of students in universities is constantly variable, it should be noted that the data used in this study are values formed as of the end of June 2013. The study was conducted on the basis of the academic year, not on the basis of the academic period. For example, the definition of the 2010 academic period instead of the 2009-2010 academic year due to the fact that January in this period belongs to the year 2010 was made. The relevant values did not include students from the open education faculties of Anatolia, Istanbul and Atatürk universities.

The universities in developed countries are categorized according to different factors such as date of establishment, teaching area, scientific yield, budget income levels, etc. In Turkey, so far, no assessment has been made on this basis. But after that, it is necessary to conduct such studies in order to make healthier determinations and shape the quality of teaching. In this study, all state universities in the country were classified into six separate categories, taking into account the years of establishment of the university. The main reason for creating categories according to the year of establishment is that universities are funded largely from the state budget, they invest with the government support they receive, and these investments constitute a significant accumulation depending on the years. Table 1 introduces the categories of state universities, established between 1933 and 2011 in Turkey. In Turkey. The hundred-three state universities were established between 1933 and 2011 during the Republic period. In this study, the human resources (students) of state universities were discussed on the basis of the categories defined in Table 1.

Table 1. The categories of State Universities on the basis of collage age.

Category	Number of Universities	Range for establishment year	The Covered Universities
A	9	1933-1971	İstanbul, İstanbul Teknik, Ankara, Ege, Karadeniz Teknik, Orta Doğu Teknik, Atatürk, Hacettepe and Boğaziçi.
B	10	1973-1978	Anadolu, Çukurova, Dicle, Cumhuriyet, Fırat, İnönü, Ondokuz Mayıs, Selçuk, Uludağ and Erciyes.
C	9	1982-1987	Akdeniz, Dokuz Eylül, Gazi, Marmara, Mimar Sinan Güzel Sanatlar, Trakya, Yıldız Teknik, Yüzüncü Yıl and Gaziantep.
D	25	1992-1994	Abant İzzet Baysal, Adnan Menderes, Afyon Kocatepe, Balıkesir, Bülent Ecevit, Celal Bayar, Çanakkale Onsekiz Mart, Dumlupınar, Gaziosmanpaşa, Gebze Yüksek Teknoloji, Harran, İzmir Yüksek Teknoloji, Kafkas, Kahramanmaraş Sütçü İmam, Kırıkkale, Kocaeli, Mersin, Muğla, Mustafa Kemal, Niğde, Pamukkale, Sakarya, Süleyman Demirel, Eskişehir Osmangazi and Galatasaray.
E	41	2006-2008	Adıyaman, Ahi Evran, Aksaray, Amasya, Bozok, Düzce, Erzincan, Giresun, Hitit, Kastamonu, Mehmet Akif Ersoy, Namık Kemal, Ordu, Recep Tayyip Erdoğan, Uşak, Ağrı İbrahim Çeçen, Artvin Çoruh, Batman, Bilecik Şeyh Edebali, Bingöl, Bitlis Eren, Çankırı Karatekin, Karabük, Karamanoğlu Mehmetbey, Kırklareli, Kilis 7 Aralık, Mardin Artuklu, Muş Alparslan, Nevşehir, Osmaniye Korkut Ata, Siirt, Sinop, Ardahan, Bartın, Bayburt, Gümüşhane, Hakkâri, Iğdır, Şırnak, Tunceli and Yalova.
F	9	2010-2011	Abdullah Gül, Bursa Teknik, Erzurum Teknik, İstanbul Medeniyet, İzmir Kâtip Çelebi, Necmettin Erbakan, Türk-Alman, Yıldırım Beyazıt, Adana Bilim ve Teknoloji.

Results and Discussion

The distribution of the number of higher education students in our country by program levels is presented in Table 2. As can be seen from this table, the number of students increased significantly during the four working years. In particular, there is a rapid increase in associate and undergraduate programs. According to the average values of four years, the 30.3 and 60.7 percent of students are teaching in associate and undergraduate degree. while 6.7 and 2.3 percent are studying in MS and Ph. Degrees, respectively. The change in the number of students by year is given in Figure 1.

Table 2. The number of total students in all state universities considered in the study for a defined period.

Program	2010		2011		2012		2013	
	Number of Students	Ratio (%)	Number of Students	Ratio (%)	Number of Students	Ratio (%)	Number of Students	Ratio (%)
Associate	559.505	32,1	560.866	30,2	623.700	29,4	704.240	29,4
Undergraduate	1.018.957	58,5	1.150.200	61,9	1.309.183	61,6	1.460.495	60,9
Total	1.578.462	90,6	1.711.066	92,1	1.932.883	91,0	2.164.735	90,3
MS Degree	120.997	7,0	106.514	5,7	142.835	6,7	177.011	7,4
Ph. Degree	42.260	2,4	40.349	2,2	48.065	2,3	55.372	2,3
Total	163.257	9,4	146.863	7,9	190.900	9,0	232.383	9,7
General Total	1.741.719	100	1.857.926	100	2.123.783	100	2.397.118	100
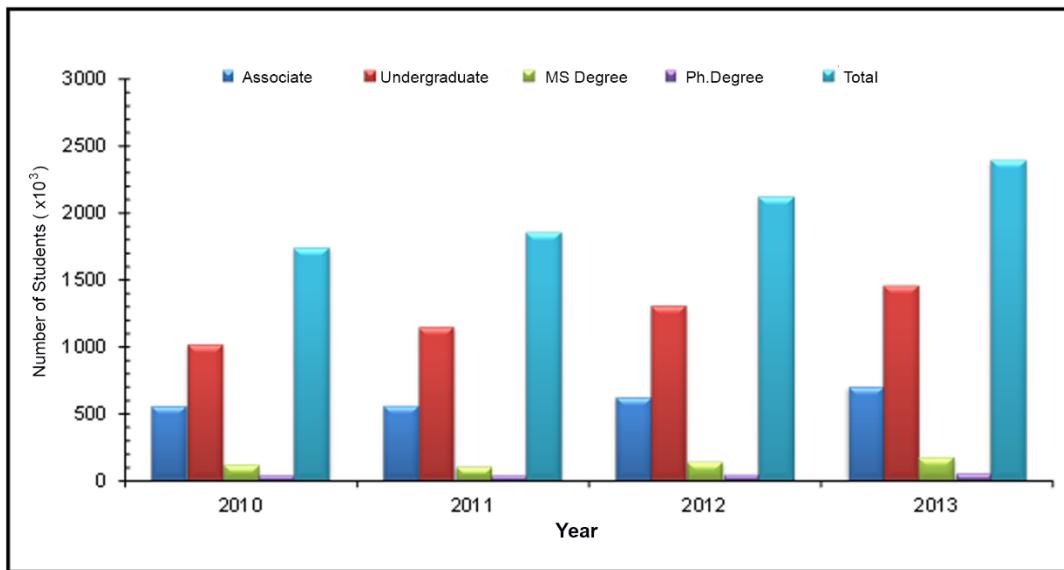
Figure 1. Programs and number of students in all state universities considered for this study.

In Table 3, the values related to the number of students of associate degree programs in the state universities included in the institutional structure of higher education in Turkey are presented. A graphical representation of the relevant data is shown in Figure 2. In Turkish higher education system, the main weight of associate degree programs is taken by the D-category universities. According to four-year data, the forty percent of the students in the total associate degree programs throughout the country are teaching at Category D universities, More than one quarter (26.0%) of all associate students are teaching in Category E with 41 universities established between 2006-2008. The lowest associate degree student value is numerically and proportionally found in the Category A universities for a defined period.

The distribution of student numbers in undergraduate programs by the categories is more balanced than in associate degree programs (table 4). The largest numerical and proportional quantities belong to the universities in Category D. A graphical representation of the relevant data along with others, is shown in Figure 2.

Table 3. The number of associate (pre-undergraduate) students for the university categories for a defined period.

University Categories	2010		2011		2012		2013	
	Number of Students	Ratio (%)	Number of Students	Ratio (%)	Number of Students	Ratio (%)	Number of Students	Ratio (%)
A-Category (9 universities)	42.181	7,5	44.812	8,0	49.976	8,0	54.505	7,7
B-Category (10 universities)	88.226	15,8	87.307	15,6	98.462	15,8	109.363	15,5
C-Category (9 universities)	55.257	9,9	60.729	10,8	68.787	11,0	75.116	10,7
D-Category (25 universities)	236.571	42,3	224.841	40,1	241.139	38,7	273.266	38,8
E-Category (41 universities)	137.270	24,5	143.177	25,5	165.336	26,5	191.990	27,3
F-Category (9 universities)	-	-	-	-	-	-	-	-
Total	559.505	100	560.866	100	623.700	100	704.240	100
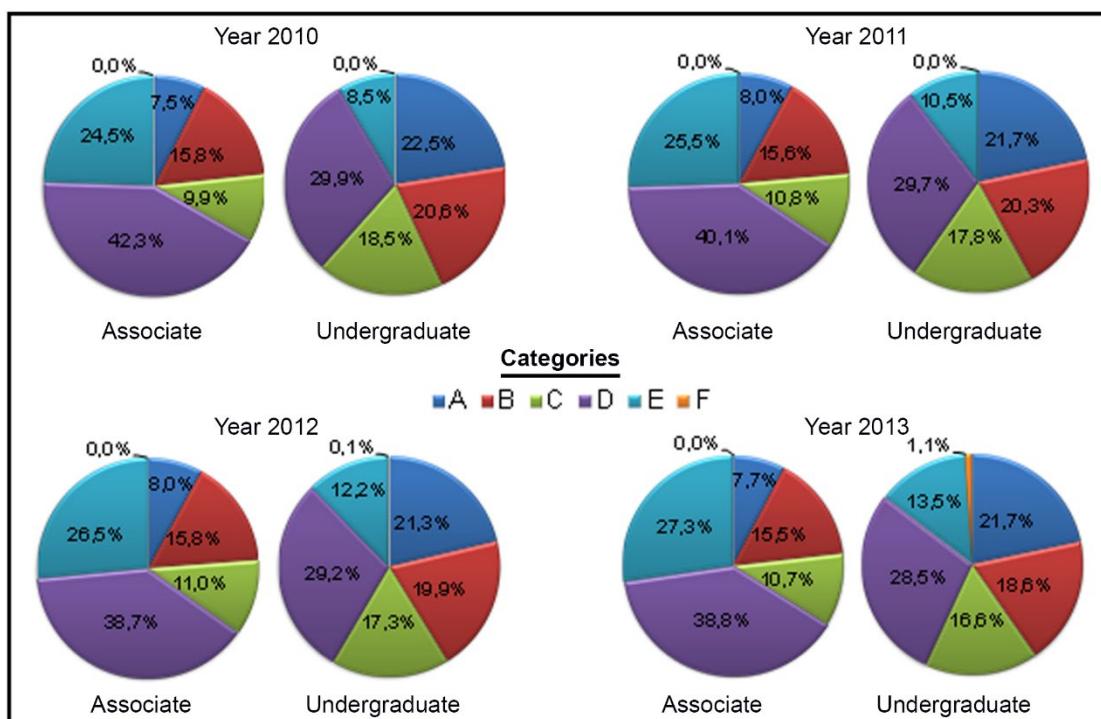
Figure 2. Rate of number of associate and undergraduate students on the basis of university categories.

Table 4. The number of undergraduate students for the university categories for a defined period.

University Categories	2010		2011		2012		2013	
	Number of Students	Ratio (%)	Number of Students	Ratio (%)	Number of Students	Ratio (%)	Number of Students	Ratio (%)
A-Category (9 universities)	229.532	22,5	249.332	21,7	279.219	21,3	316.812	21,7
B-Category (10 universities)	209.496	20,6	233.067	20,3	261.029	19,9	271.007	18,6
C-Category (9 universities)	188.227	18,5	204.631	17,8	226.269	17,3	242.436	16,6
D-Category (25 universities)	304.923	29,9	342.244	29,7	381.932	29,2	416.530	28,5
E-Category (41 universities)	86.779	8,5	120.926	10,5	159.646	12,2	196.582	13,5
F-Category (9 universities)	-	-	-	-	1.088	0,1	17.128	1,1
Total	1.018.957	100	1.150.200	100	1.309.183	100	1.460.495	100

The distribution of number of MS Degree students and their proportional size are given in Table 5 according to the University categories.   Although the number of MS Degree students is relatively higher in Category A, its distribution in categories A, C and D is balanced. The 4.8 percent of all MS Degree students are teaching in the Category E. However, the proportional sizes of this category have been higher in later years of working period. A graphical representation of the relevant data is given in Figure 3.

Table 5. The number of MS Degree students for the university categories for a defined period.

University Categories	2010		2011		2012		2013	
	Number of Students	Ratio (%)	Number of Students	Ratio (%)	Number of Students	Ratio (%)	Number of Students	Ratio (%)
A-Category (9 universities)	37.685	31,1	33.901	31,8	43.105	30,2	50.779	28,7
B-Category (10 universities)	21.955	18,2	17.270	16,2	23.332	16,3	26.260	14,8
C-Category (9 universities)	30.275	25,0	25.913	24,3	35.465	24,8	41.701	23,6
D-Category (25 universities)	27.062	22,4	24.376	22,9	33.828	23,7	43.892	24,8
E-Category (41 universities)	4.020	3,3	5.054	4,8	6.947	4,9	11.017	6,2
F-Category (9 universities)	-	-	-	-	158	0,1	3.362	1,9
Total	120.997	100	106.514	100	142.835	100	177.011	100
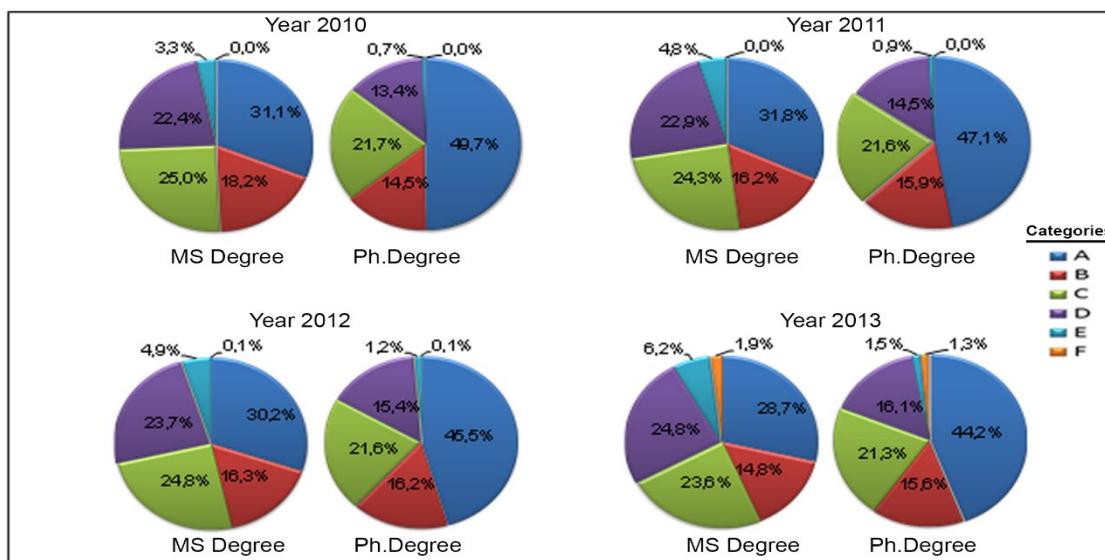
Figure 3. Rate of number of MS Degree and Ph. Degree students on the basis of university categories.

The number and proportional size of students participating in the doctoral programs of state universities in our country are given in Table 6. According to these data, an average of 46.6 percent of all doctoral students study at Category A universities. Category A universities take quite a lot of responsibility for graduate studies, especially at the doctoral level. The Category-E universities, established between 2006-2008, have a very low responsibility for doctoral teaching (1.1 percent), as opposed to those in the associate's program. A graphical representation of the relevant data, along with other data, is shown in Figure 3.

Table 6 The number of Ph. Degree students for the university categories for a defined period.

University Categories	2010		2011		2012		2013	
	Number of Students	Ratio (%)	Number of Students	Ratio (%)	Number of Students	Ratio (%)	Number of Students	Ratio (%)
A-Category (9 universities)	20.993	49,7	19.019	47,1	21.840	45,5	24.460	44,2
B-Category (10 universities)	6.145	14,5	6.429	15,9	7.792	16,2	8.654	15,6
C-Category (9 universities)	9.151	21,7	8.692	21,6	10.366	21,6	11.818	21,3
D-Category (25 universities)	5.677	13,4	5.841	14,5	7.423	15,4	8.933	16,1
E-Category (41 universities)	294	0,7	368	0,9	580	1,2	817	1,5
F-Category (9 universities)	0	0	0	0	64	0,1	690	1,3
Total	42.260	100	40.349	100	48.065	100	55.372	100

If associate and undergraduate programs are evaluated together, the thirty-two percent of students in these programs are in the Category D universities. Similarly, if Master's and doctoral programs are evaluated together, approximately forty percent of students studies at Category-A universities.   Figure 4 presents the change in student numbers of six separate categories according to program levels for 2010, 2011, 2012 and 2013. The most striking result in this figure is the decrease in the number of doctoral students in the Category-A universities depending on time.
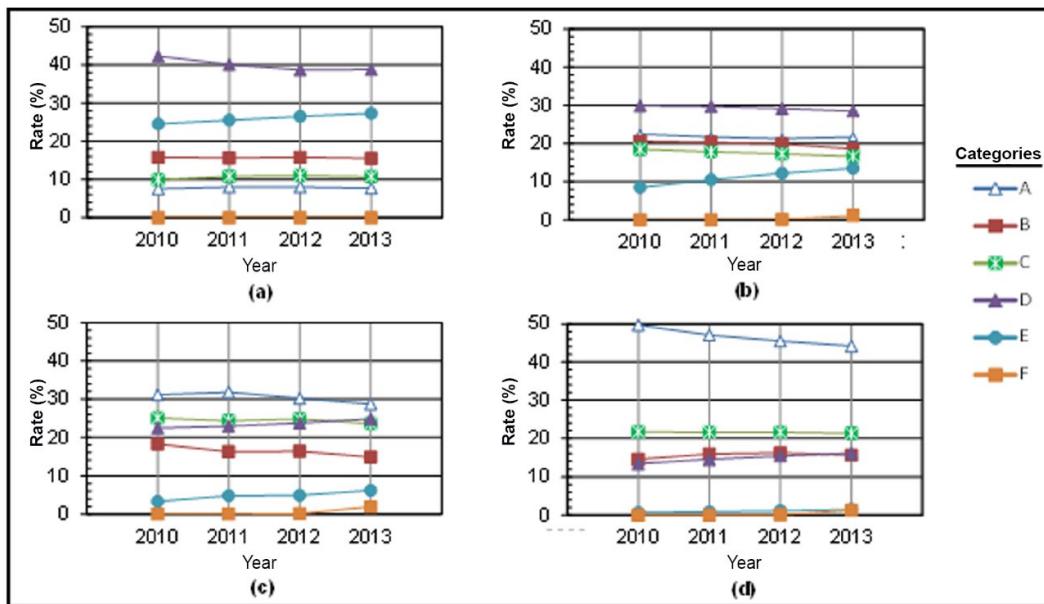
Figure 4. Change of on the ratios of student numbers on the basis of university categories and programs.

Conclusions

The Turkish higher education system has experienced a serious expansion (massization) process since the end of the 2000s. The number of students at public universities increased by an average of 38% in the four years that this study was conducted. It is known that this rate increased much faster in the following years. Today, the number of students in the higher education system in our country has exceeded 7.5 million. This process of expansion has reduced the quality of teaching, and due to some external factors that occurred later, the educational structure of higher education institutions has been disrupted. In other words, the transformation envisaged in the strategic plan for the universities has not been achieved. For this purpose, it should take some new measures. In particular, some departments opened during the expansion process should be closed and the system should be normalized and the number of faculty members should be increased rapidly without compromising quality. The A-Category universities can be provided to appeal to master's and doctoral students in their entirety in order to train faculty members and increase the country's scientific culture. The associate degree programs should be re-recognized and removed from the higher education system and managed by a separate institutional structure. In this way, the real situation of higher education institutions across the country can be analyzed much better.

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DEVELOPMENT OF ANTIBACTERIAL TOOTHPASTE FORMULATION USING NATURAL RAW MATERIALS

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ABSTRACT
New treatment methods are very important in the treatment of oral cavity diseases such as tooth decay, gingivitis, and general oral infections. Essential oils have long been used as antibacterial agents due to having biologically active compounds with important health effects. This study aimed to assess the antibacterial and antibiofilm effects of toothpastes with clove and thyme essential oils and propolis extract against bacteria associated with oral diseases. Toothpastes were formulated with 3% concentrations of the clove and thyme essential oils and propolis extract and evaluated for antibacterial and antibiofilm activities. For this purpose, antibacterial activity of toothpastes against Staphylococcus aureus ATCC6538 bacteria were determined and maximum antibacterial activity was observed with clove oil.
Keywords: Toothpaste; clove oil; thyme oil; propolis; oral flora; Staphylococcus aureus.

Introduction

Dental and gum diseases are among the most important health issues in the world. It is important that oral-dental health is closely related to main health and wellbeing. Many problems such as bad breath, caries, plaque and tooth structures, gum diseases, and tooth sensitivity may occur due to the lack of dental cleaning. In order to prevent these problems and to have a good oral health, functional oral care products should be used correctly, and daily preventive care should be applied.

The oral cavity creates favorable conditions for the reproduction of aerobic, facultative, and anaerobic microorganisms with 35-36°C temperature, humidity, various nutrients, and variable oxygen exposure. Therefore, it is a highly heterogeneous environment with optimal physicochemical conditions and high nutrient availability for bacterial communities (Carvalho et. al, 2020).

The presence of commensal bacteria is very important for the physiology of the oral cavity; however, the formation of pathogenic microorganisms can lead to serious health problems, particularly biofilm-related infections. *Actinomyces* and *Streptococcus* biofilms may trigger some of the most common oral cavity diseases such as dental caries, gingivitis, and periodontitis (Verkaik et. al, 2011). Therefore, the development of antibiofilm agents represents an important strategy in combating oral cavity infections and attracts considerable attention.

Oral microbial flora is the region with the highest number of microorganisms compared to other regions of the human body. However, according to the data obtained by molecular biological methods, it contains more than 700 microorganism species. These microorganisms are members of colonies of microorganisms that cover the oral surface, also called dental plaque or oral biofilm. *Streptococcus salivarus* which constitutes 50% of *Streptococci* on the tongue, cannot attach to the hard tissues of the teeth. On the other hand, *Streptococcus mutans* that can adhere to tooth hard tissues very well, cannot hold onto the tongue surface. The tooth is one of the most suitable places for *Streptococcus sanguis* and *Streptococcus mutans* to settle. They constitute the dominant streptococcal flora on the mouth and tooth surface (Hepdeniz et. al, 2017). The list of the main bacteria found in the oral flora is presented in Table 1. Oral bacteria are *Streptococcus, Lactobacillus, Staphylococcus, Corynebacterium* and especially bacteroides group anaerobes (Özan et. al, 2015).

Streptococcus mutans is the primary oral colonizer. Bacteria adhere to the tooth surface and create favorable conditions to adhere secondary colonizers such as *Lactobacillus species* (Verkaik et. al, 2011).

Dental biofilm formation is a natural process in the oral environment, but it should be controlled with regular brushing to prevent the development of caries and periodontal diseases. Brushing alone is not enough to prevent the development of periodontal diseases and caries and to destroy oral biofilm (Verkaik et. al, 2011).

Table 1. Microorganisms frequently isolated from the oral cavity

ANAEROBIC BACTERIA	
Gram-negative rod-shape bacteria	
Porphyromonas	*P. gingivalis, P. endodontalis, P. catoniae*
Prevotella	*P. oralis, P. oris, P. buccae, P. corporis, P. denticola, P. loescheii, P. intermedia, P.nigrescens, P. melaninogenica*
Fusobacterium	*F. nucleatum spp. nucleatum, spp. vincentii, spp. polymorphum*
Mitsuokella	*M. dentalis*
Selenomonas	*S. sputigena, S. noxia*
Campylobacter	*C. sputorum, C. rectus, C. curvus*
Treponema	*T. denticola, T. vincentii, T. socranski*
Bacteroides	*B. forsythus*
Gram-positive rod-shape bacteria	
Eubacterium	*E. alactolyticum, E. lentum, E. yurii*
Propionibacterium	*P. acnes, P. propionicus, P. jensenii, P. granulosum, P. avidum*
Lactobacillus	*L. catenaforme, L. crispatus, L. oris, L. uli, L. grasseri*
Actinomyces	*A. israelii, A. odontolyticus, A. meyeri*
Arachnia	*A. propionica*
Gram-negative spherical bacteria	
Veillonella	*V. parvula, V. alcalescens*
Gram-positive spherical bacteria	
Peptostreptococcus	*P. asaccharolyticus, P. magnus, P. micros, P. anaerobius P. prevotii*
FACULTATIVE ANAEROBIC BACTERIA	
Gram-negative rod-shape bacteria	
Eikenella	*E. corrodens.*
Capnocytophaga	*C. ochracea, C. sputigena, C. gingivalis, C. haemolytica, C. granulosa*
Actinobacillus	*A. actinomycetemcomitans.*
Haemophilus	*H. aphrophilus H. influenzae, H. parainfluenzae, H. paraphrophilus, H. segnis*
Gram-positive rod-shape bacteria	
Corynebacterium	*C. xerosis, C. matruchotii*
Actinomyces	*A. naeslundii, A. viscosus*
Rothia	*R. dentocariosa*
Lactobacillus	*L. acidophilus, L. brevis, L. buchneri, L. casei, L. salivarius, L. fermentum*
Gram-negative spherical bacteria	
Neisseria	*N. flavescens, N. mucosa, N. sicca, N. subflava*
Branhamella	*B. catarrhalis*
Gram-positive spherical bacteria	
Streptococcus	*S. mutans, S. sanguis, S. salivarius, S. sobrinus, S. rattus, S. downei, S. mitis,S. milleri, S. oralis, S. intermedius, S. constellatus*
Staphylococcus	*S. aureus, S. epidermidis*
Enterococcus	*E. faecalis, E. faecium*

Herbal toothpastes containing natural antibacterial agents are a good alternative to reduce the risk of oral diseases in both children and adults. Developing natural antibiofilm and antibacterial agents which are safe alternatives that support oral health, may be an effective method for the prevention and control of oral cavity pathologies. In the study, the herbal toothpaste formulations as safe and natural antibiofilm alternatives against cariogenic and periodontal diseases which contained thyme oil, clove oil and propolis extract were developed and tested for their antibacterial efficacy to evaluate the antibacterial and antibiofilm effects.

Materials and Methods

The thyme oil, clove oil and propolis extract added formulations were prepared by using the base formulation given in Table 2.

Table 2. Toothpaste base formulation (%)

Sorbitol	30-35%
Aqua	20-30%
Silica	15-20%
Glycerin	10-15%
PEG 8	2-5%
Sodium Lauryl Sulfate	1-3%
Dicalcium Phosphate Dihydrate	1-3%
Cellulose Gum	1-3%
Xanthan Gum	1-3%
Sodium Fluoride – Active Ingredient 0.32% (1470 ppm F)	0.32%
Sodium Saccharin	0.20%

The formulations by adding 3% concentration of thyme oil, clove oil and propolis extract to the base formulations were developed and named as in Table 3.

Tablo 3. Newly developed Formulations

F1	Base Formulation
F2	Base Formulation + 3% Thyme oil
F3	Base Formulation + 3% Clove oil
F4	Base Formulation + 3% Propolis Extract

Thyme oil, clove oil and propolis extract were purchased from Talya Herbal Products Industry and Trade Inc. The antibacterial tests EN 1276 were performed by accredited laboratories.

Results

The use of natural active ingredients in cosmetic products has taken attention. The toothpaste formulations with different oils and extracts were developed to analyze their antibacterial and antibiofilm effects. Therefore, 3% thyme oil, clove oil and propolis extract were added to the base formulation.

GC/MS (Gas chromatography/mass spectrometry) analysis taken from the supplier shows the major components of thyme oil and clove oil and their percentages in Table 4.

Table 4. Major components of thyme oil and clove oil

	Components	Amounts (%)
Thyme Oil	Thymol	2.36
	Carvacrol	41.45
Clove Oil	Eugenol	64.53
	Caryophyllene	8.21
	Eugenyl acetate	5.48

Antibacterial efficacy performances are evaluated by EN 1276 standard test method. The logarithmic reductions of *Staphylococcus aureus* ATCC 6538 are tested. Minimum 5 log reduction is needed for a positive test result for *Staphylococcus aureus* strains. The contact duration of the antibacterial formulation is standardized as 5 minutes and incubation temperature is 37°C. The results were compared in Table 5.

Table 5. Antibacterial efficacy results of the formulations on *Staphylococcus aureus* strain

Bacteria	Contact duration (min)	Activity range	Logarithmic reduction (cfu/ml)			
			F1	F2	F3	F4
Staphylococcus aureus ATCC 6538	1	>5	5.50	5.89	6.03	5.70
Efficacy result			(+)	(+)	(+)	(+)

The logarithmic reduction values of all formulations are higher than 5 log after 5 minutes contact duration. It has been observed that F2 and F4 are very close to base formulation F1. However, F3 containing clove oil has an obvious difference than others with 6.03 log reduction in bacterial count. It may be because of high content of Eugenol as 64.53% of clove oil. In addition, thyme oil contains 41.45% carvacrol, it may have affected the antibacterial activity performance in F2 succeeding F3.

It has been known that thyme plant has antibacterial, antiviral, antioxidant, antilipidemic and antifungal effects. Thymol in thyme essential oil is a terpenic substance and has antiseptic, antibacterial, antispasmodic, antiasthmatic, expectorant and fungicidal effects, it has 30 times more antiseptic effect and 4 times less toxic effect than phenols. Thymol is also used in dentistry as an antioxidant for temporary fillings (Çetin et. al, 2013).

Recently, thymol and its derivatives have received a lot of attention in applications such as various biological functions, phyto-pharmaceutical preparations, food preservatives. It was found that the most effective compound in essential oils was thymol with the lowest minimum inhibitory concentration (MIC, 35-128 µg / ml) followed by eugenol and carvacrol. The Botelho group tested the antimicrobial activity of thymol against cariogenic bacterial species of the genus *Streptococcus* and *Candida albicans* with MIC values ranging from 0.625 to 10.0 mg /mL. In another study, the aerial parts of *Origanum vulgare L.* were tested against 26 MSS and 21 MRS using an agar dilution method. The results showed that the best MIC values were for thymol (0.03-0.06% v/v) and derivatives of thymol 2- (allyloxy) -1-isopropyl-4-methylbenzene, 4-allyl-2-isopropyl-5-methylphenol, 2-isopropyl-5-methyl-4-propylphenol (Dheer et. al, 2019).

Clove oil helps reduce stomatitis and gingivitis that contains eugenol substance. The eugenol substance is a natural anesthetic, analgesic (pain reliever) and antibacterial. In addition, clove oil shows antibacterial activity by preventing the growth of gram positive and gram-negative bacteria. In addition, it is known to have fungistatic and antiviral effects (Mohammadı Nejad et. al, 2017).

In a study, when clove essential oil was analyzed using GC-MS, 18 basic chemical compounds were extracted and tested for potential antioxidant activities. Eugenol is an important active ingredient representing 90% of clove essential oil and has been approved by the FDA for use as a food additive. In addition to its antioxidant activity, clove oil has bactericidal properties against many types of bacteria such as *Salmonella, Staphylococcus, Listeria* and *Escherichia* (Abdelkhalek et. al, 2020).

In a study by Carvalho and colleagues, toothpastes were formulated with different concentrations of the most active essential oils and evaluated for their antibacterial and antibiofilm activities. Minimum inhibitory concentration (MIC) and antibiofilm activity was determined against *Staphylococcus aureus, Streptococcus mutans*, *Lactobacillus lactis* and *Enterococcus faecalis*. The MIC was determined as the lowest concentration of essential oil that does not cause bacterial growth. The antibiofilm activity of clove, thyme, and cinnamon essential oils at 1×, 2×, and 4×MIC against *S. mutans* did not differ from that of the control (0.12 % chlorhexidine gluconate mouthwash) and has been found to completely disrupt *S. mutans* biofilms. Microbial inhibition was categorized as strong (MIC < 0.5 mg/mL), moderate (0.5≤MIC ≤ 1.5 mg/mL), and weak (MIC > 1.5 mg/mL). When the results were examined, the MIC values of the control were found as follows: 0.05 for *Streptococcus mutans*, 0.05 for *Staphylococcus aureus*, 0.25 for *Lactobacillus lactis*, 0.05 for *Enterococcus faecalis*. The MIC values of clove essential oil were found as 0.315 for *Streptococcus mutans*, 0.625 for *Staphylococcus aureus*, 1.25 for

Lactobacillus lactis, 1.25 for *Enterococcus faecalis*. Clove essential oil caused strong and moderate inhibition against *S. mutans* and *S. aureus* and weak inhibition of *L. lactis* and *E. faecalis*. The MIC values for thyme essential oil are as follows: 0.625 for *Streptococcus mutans*, 0.625 for *Staphylococcus aureus*, 0.315 for *Lactobacillus lactis*, 0.625 for *E. faecalis*. In MIC tests, thyme essential oil showed moderate inhibition against *S. mutans, S. aureus, E. faecalis* and strong inhibition against *L. lactis* (Carvalho et. al, 2020).

Propolis; a honeybee hive product contains numerous active compounds such as phenolic acids, esters and flavonoids. Thus, it has a wide pharmacological potential, including anti-bacterial, anti-fungal, anti-protozoal, hepatoprotective, antioxidant, anti-inflammatory, anti-viral, anticancer, and anti-tumor properties (Anjum et al, 2019). Also, adding ethanolic propolis extract to the composition of mouthwashes and toothpastes enhances the prevention of microbial infection and is effective in treating gingivitis. The antibacterial activity of propolis is thought to be due to flavonoids and aromatic acids and esters in the resin. Galangin, pinocembrin and pinobanksin have been identified as the most effective flavonoids against bacteria. Ferulic and caffeic acid also play a role in the bactericidal effect of propolis (Carvalho et. al, 2020).

In an antibacterial study on Staphylococcus aureus strain, propolis was found to interact severely with streptomycin and cloxacillin, and moderately synergistically with chloramphenicol, cephradine, and polymyxin B. It has been observed that propolis solution shows antibacterial activity in vitro, inhibits the adhesion of cells and formation of water-soluble glucan. According to the data obtained from the studies conducted, it has been observed that propolis solutions prepared in appropriate concentrations have inhibitory properties on oral microorganisms and have no toxic effects on oral tissues. It is also known that propolis prevents the formation of tooth decay and periodontal disease (Özan et. al, 2015).

Conclusion

New effective methods of herbal toothpastes supported natural antibacterial and antibiofilm agents provide to prevention and control of oral cavity pathologies.

The results of this study pointed out that developed herbal toothpastes exhibit statistically higher antibacterial activity against *Staphylococcus aureus* than their initial forms after the addition of essential oils.

As can be seen from the results of EN 1276, thyme oil, clove oil and propolis extract components affected the logarithmic reduction values. The plant that oil is obtained from has some parameters such as collection time, drying patterns, drying temperature, and duration that affect the volatile composition of the plants. For this reason, the parameters should be taken into consideration, and work with oils and extracts with appropriate composition.

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THE ADAPTATION AND VALIDITY OF SARC-F SCALE IN INDIVIDUALS OVER THE AGE OF 65

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ABSTRACT

This study aimed to investigate the effects of eating habits on sarcopenia in individuals over 65, to adapt the SARC-F scale which is used for the early diagnosis of sarcopenia into Turkish and to investigate the validity of the scale in individuals over 65. The research was conducted with 91 subjects, including 45 females and 46 males, who presented to Mersin Private Akademi Hospital. A questionnaire that consists of general information, anthropometric measurements, MNA screening test and the SARC-F scale was administered to all participants. Relationship between the MNA screening test, which is used to evaluate nutritional status, and the SARC-F scale, which is used for the early diagnosis of sarcopenia, was found to be statistically significant (p=0.001). Evaluating the MNA test and SARC-F scale according to gender, it was found that there was a statistically significant relationship between the SARC-F score and gender (p=0.004), whereas there was no relationship between the MNA score and the same (p>0.05). According to the sarcopenia risk status, there was a statistically significant difference in terms of body weight, height, fat-free mass, hand grip strength and finger grip strength. Statistical evaluation that was conducted to check the reliability of the SARC-F screening test revealed a Cronbach's Alpha value of 0.60. Evaluation of validity showed that the KMO value was higher than 0.50 and the factor analysis was reliable since the Bartlett's Test provided statistically significant results. In conclusion, eating habits that involve a sufficient and balanced diet have positive effects on the prevention and treatment of sarcopenia and the Turkish version of the SARC-F scale is valid and reliable.

Keywords: Sarcopenia, malnutrition, geriatric, muscle mass, muscle function, SARC-F.

Introductıon

The phenomenon that has emerged and gained global importance with the 21st century is "population ageing" (Kirkwood, 2003). Therefore, the interest in studies concerning senescence and the prevention and treatment of health problems encountered in the elderly has been increasing (Smith, 2005). One of the age-related dramatic and clinical anatomic changes in humans occurs in the skeletal muscle. Sarcopenia, defined as loss of muscle mass and strength, is a syndrome that cannot be ignored due to the fact that all people lose their skeletal muscle mass as they age (Cruz, 2010). Sarcopenia is very common and like most geriatric syndromes, it often goes unnoticed in the early stages and becomes more apparent after a fall or injury (Yu,2016, Fielding,2011). The SARC-F questionnaire, referred to as a rapid screening test, was developed in 2013 to enable health professionals to evaluate the risk of sarcopenia rapidly and easily (Charlotte, 2016).

Further studies are necessary in order to address the lack of widely accepted diagnostic criteria for identifying sarcopenic patients. In this study, it was aimed to investigate the effects of eating habits on sarcopenia and determine whether the Turkish form of 'A Simple Questionnaire to Rapidly Diagnose Sarcopenia (SARC-F)' scale developed by Malmstrom, T.K. and Morley, J.E et al. in 2013 is a valid and reliable tool for the patients in Turkey, considering that it can be a method suitable for use in the diagnosis of sarcopenia in geriatric patients as well as contributing to the limited number of studies in this field.

Factors Affecting Eating Habits in the Elderly

Ensuring and maintaining a good nutritional health is necessary for physical and cognitive functions, prevention or delaying of chronic diseases and disease-related complications and ensuring the general quality of life (Institute, 2001, Report,2003). Malnutrition represents nutritional health, deficiency and imbalances as well as extreme conditions such as obesity, wherein it is affected by a number of factors related to food intake. These factors include food insecurity/food shortages, lack of personal resources, functional impairment (insufficiency of food acquisition, preparation and eating), social isolation, multiple diseases, oral problems, limited knowledge of nutrition and regular use of multiple drugs (Sharkey,2003, White,1991).

Personal and social factors affecting food intake should not be ignored while developing an age-appropriate diet in order to facilitate compliance. Therefore, it is required to define the socioeconomic, demographic and health-related risk factors that may directly or indirectly affect nutrition in the elderly. Age-related loss of vision, tooth loss, difficulty chewing and swallowing, decreased sense of taste and smell would limit the food selection and lead to decreased food consumption as well as reduced liking for meals. However, lifestyle habits or changes, living

alone and cultural differences also play an important role in food selection. Bad eating habits, which are commonly observed in older adults, reveal the need to focus on these factors (Rakıcıoglu,2003, WHO,2002, Pekcan, 2016).

Malnutrition in Geriatrics

Malnutrition occurs when individuals are unable to fully use the food they consume as a result of disease or other causes (secondary malnutrition), have too much calorie intake (overnutrition) or insufficient intake of essential nutrients (malnutrition or protein-energy malnutrition). However, despite these definitions, there is no universally accepted definition for malnutrition. Malnutrition in the elderly is a common problem which manifests independently or as a complication of disease (Savaş, 2010).

Older adults are among the highest risk groups in terms of malnutrition in the general population. Therefore, malnutrition is an important issue that should be addressed in this age group. Loss of muscle and adipose tissue due to both aging and malnutrition causes the body composition to change. It is important to know which changes stem from ageing in order to define the changes caused by malnutrition accurately (Verbrugghe, 2013).

Sarcopenia

One of the most dramatic and clinical anatomic changes associated with age in humans occurs in the skeletal muscle. In 1989, Irwin Rosenberg used the term 'sarcopenia' to refer to the age-related process of skeletal muscle loss (Rosenberg, 1989). Sarcopenia derives from the Greek works sarx (flesh) and penia (loss). Sarcopenia, for which the accepted definition is still lacking in research and clinical practice, is accompanied by decreased movement ability, decreased physical endurance, slowed gait speed and physical limitation (Cesari, 2006).

Due to the lack of a globally accepted definition for sarcopenia, which was first defined by Rosenberg, the European Geriatric Medicine Society (EuGMS) encouraged The European Working Group on Sarcopenia in Older People (EWGSOP) to establish consensus diagnostic criteria for sarcopenia in 2009. The EWGSOP divided sarcopenia into three stages: presarcopenia, sarcopenia and severe sarcopenia. In the pre-sarcopenia stage, there is decreased muscle mass while muscle strength and physical performance remain unaffected. In the sarcopenia stage, there is decreased muscle strength or performance along with a decrease in muscle mass. In severe sarcopenia, there is decreased muscle mass, muscle strength and performance, i.e. a decrease in all three criteria (Cruz-Jentoft, 2010).

The development of sarcopenia involves many factors such as aging, genetic characteristics, lifestyle and conditions, malnutrition, immobility/sedentary lifestyle, chronic diseases and drug use. Therefore, sarcopenia can sometimes have a single cause or occur due to the combination of various factors. Therefore, it is beneficial in clinical practice to divide sarcopenia into two: primary sarcopenia that develops only due to aging without any other cause and secondary sarcopenia that develops due to one or more factors. Since the etiology of sarcopenia is multifactorial in many older adults, it may not be possible distinguish between primary and secondary sarcopenia (Cruz-Jentoft, 2010).

There are many techniques to evaluate muscle mass. CT, MRI or DEXA are among the methods that can be used for muscle mass measurement. However, DEXA, BIA and anthropometric measurements are preferred in clinical practice. One of these measurements should be selected by also considering the accessibility, applicability and cost factors (Cruz-Jentoft, 2010).

Muscle strength is best measured using a hand-held dynamometer and requires the best mean value of three measurements (Fried, 2001).

Nutrition Screening Tools

A number of questionnaires have been developed and approved for the assessment of nutritional status. Simplified Nutritional Assessment Questionnaire (SNAQ) is a survey consisting of four questions with high sensitivity and specificity to identify older people who have a risk of weight loss (Wilson, 2005). The SCREEN II (Seniors in the Community: Risk Evaluation for Eating and Nutrition) index was developed by Keller et al. This index determines nutritional status by four factors: food intake, physiological, adaptation and functional condition. Test reliability was confirmed by repeatability and it is widely used in Canada (Keller, 2006; Keller, 2005; Keller, 2001).

"Malnutrition Universal Screening Tool" (MUST) is a simple 5-step screening tool recommended by the European Society of Parenteral and Enteral Nutrition (ESPEN) and the British Association for Parenteral and Enteral Nutrition (BAPEN) for use in both elderly inpatients and outpatients. In cases where BMI cannot be measured in the MUST test, it was suggested to check the arm wrist-elbow (ulna) length to determine the height and estimate BMI from the MUAC (mid-upper arm circumference) measurement. Therefore this test was recommended for

inpatients, since it used an alternative method to estimate height. In addition, while the risk of malnutrition can be mentioned with a BMI below 22 kg/m2 in the elderly, MUST considers a BMI of 20 kg/m2 normal, which is accepted as a disadvantage (Stratton, 2004, Stratton,2006, Visvanathan,2003).

The Appetite Hunger and Sensory Perception (AHSP) questionnaire was developed in nursing homes in the Netherlands. This questionnaire focuses on loss of appetite and changes in the sense of taste and smell. It performed more successfully in healthy older adults than in the underweight elderly (Mathey,2001; Savina,2003).

The Subjective Global Assessment (SGA) is a screening tool that evaluates the level of nutrition in hospitalized patients (McCann, 1999). This screening tool includes a short physical examination that involves weight change, food intake, medical history of gastrointestinal symptoms and functional disorders, subcutaneous fat, muscle loss, edema and acid loss. It was mainly validated for young individuals with gastrointestinal disorders and there are studies suggesting that this tool is not commonly preferred in evaluating healthy older adults (Guigoz, 2006).

The Mini Nutritional Assessment (MNA), proposed by ESPEN for use in the elderly in 2002, consists of global assessment questions, specific dietary questions, self-perception and anthropometric measurements (Vellas, 2006). This screening test has the highest and widely verified reliability and validity. MNA can detect malnutrition long before the pronounced changes in body weight or serum protein levels, since it contains more sophisticated measurements than other tests (Green, 2006).

The SARC-F scale was developed as a rapid screening test for the diagnosis of sarcopenia. This questionnaire enables health professionals to evaluate the risk of sarcopenia rapidly and easily. The questionnaire consists of five components: strength, assistance walking, rise from a chair, climb stairs and falls. These components have been selected so as to reflect health changes associated with the outcomes of sarcopenia. The SARC-F score ranges from 0 to 10, wherein 0-3 points indicates healthy patients, whereas 4 points and above indicates symptomatic patients (Malmstrom, 2016).

Materıals And Methods
Time, place and sample of the study: This study included 120 healthy individuals aged 65 and older who presented to Mersin Private Akademi Hospital between May 2017 and November 2017. However, the study was completed with data from 91 questionnaires, since those with incomplete data were not included in the evaluation.

General study plan: In this study, in order to investigate the effects of eating habits on sarcopenia in healthy patients aged 65 and older and determine whether the Turkish form of 'A Simple Questionnaire to Rapidly Diagnose Sarcopenia (SARC-F)' scale developed by Malmstrom, T.K. and Morley, J.E et al. in 2013 is a valid and reliable tool for the patients in Turkey, the SARC-F scale was used along with the MNA test and a questionnaire that included anthropometric measurements, three-day food consumption log and frequency of food consumption to assess the nutritional status. The questionnaire also investigated the physical activity status. Data from the study: face-to-face interview method was used by the researcher in order to accurately and exactly determine patient information.

Statistical Analysis: Cronbach's alpha coefficient and Kaiser-Meyer-Olkin (KMO) values were studied as well as a factor analysis conducted for the reliability and validity study of the SARC-F scale in Turkish. Statistical analysis of the obtained data was performed with the IBM SPSS 21 software package, MedCalc statistical software package and e-picos software. Parametric tests were used without testing for normality due to compliance with the central limit theorem. Continuous variables were expressed with mean and standard deviation and minimum and maximum values, whereas categorical variables were expressed with frequency and percentage values. Student's T test was used to compare the mean values of two groups and One-Way ANOVA to compare the mean values of more than two groups. Tukey's Post Hoc test was used in case of a difference detected in ANOVA. Chi-Square test was used to evaluate the relationships between categorical variables. 95% confidence interval was used for all tests performed within the scope of this study and $p < 0.05$ was considered statistically significant.

Results
Results of the Factor Analysis for the Validity of the SARC-F Scale
A factor analysis was conducted to determine the validity of the SARC-F scale and to obtain the functional dimensioning by identifying factor weights of the items included in the scale. Suitability of data to factor analysis was tested with the Kaiser-Meyer-Olkin (KMO) and Bartlett's tests before conducting the factor analysis. For the evaluated scale that consisted of 5 items, KMO value was found to be 0.70 and the Bartlett's test result was as follows: $\chi2 = 109.568$ ($p \le 0.05$) (Table 1). A KMO value higher than 0.60 and a significant Bartlett's test result means that the data is suitable for factor analysis (Büyüköztürk, 2011).

Table 1: Data on the Suitability of the SARC-F Scale to Factor Analysis

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.70
Bartlett's Test of Sphericity	Chi-square	109.568
	P value	<0.001

Results of the Reliability Analysis of the SARC-F Scale

Cronbach's Alpha coefficient was used for the reliability analysis of the scale. A Cronbach's Alpha between 0.80 and 1, 0.60 and 0.79, 0.40 and 0.60, and 0 and 0.39 indicates a highly reliable, reliable, poorly reliable and unreliable scale, respectively (Büyüköztürk, 2011). Cronbach's Alpha was found to be 0.60 for the SARC-F scale (Table 2). In accordance with this value, the scale was considered reliable.

Table 2: Results of the Cronbach Alpha Reliability Analysis for the SARC-F Scale

Factor	Number of items	Cronbach's Alpha
SARC-F Scale	5	0.60

Evaluation of the Sociodemographic Characteristics

Of the 91 subjects who participated in the study, 45 (49.5%) were female and 46 (50.5%) were male. Considering the educational status, 4.4% of the participants were illiterate, 11% were literate, 17.6% were elementary school graduates, 17.6% were middle school graduates, 28.6% were high-school graduates or had received an equivalent education and 20.9% were university graduates. Considering the classification of subjects by age, 40.7% of the participants were 70 and younger, 25.3% were between 71-74, 17.6% were between 75-80 and 16.5% were 81 and older (Table 3).

Table 3: Evaluation of the Sociodemographic Characteristics

N=91		
Variables	Number (n)	Percentage (%)
Gender		
Female	45	49.5
Male	46	50.5
Total	91	100
Educational status		
Illiterate	4	4.4
Literate	10	11
Elementary School	16	17.6
Middle School	16	17.6
High School	26	28.6
University	19	20.9
Total	91	100
Age		
<70	37	40.7
71-74	23	25.3
75-80	16	17.6
>81	15	16.5
Total	91	100

Considering the relationship between sarcopenia risk status and sociodemographic characteristics, there was a statistically significant relationship between age and risk of sarcopenia (p=0.001) (Table 4).

Table 4: Evaluation of the Relationship Between Sociodemographic Characteristics and Sarcopenia Risk Status

| N=91 | Sarcopenia status | | | | |
| | Risk | | No Risk | | |
Variables	Number (n)	Percentage (%)	Number (n)	Percentage (%)	P value
Gender					
Female	36	54.5	9	36	0.11
Male	30	45.5	16	64	
Total	66	100	25	100	
Educational status					
Illiterate	4	6.1	-	-	0.07
Literate	8	12.1	2	8	
Elementary School	13	19.7	3	12	
Middle School	13	19.7	3	12	
High School	13	19.7	13	52	
University	15	22.7	4	16	
Total	66	100	25	100	
Age					
<70	17	25.8	20	80	<0.001*
71-74	20	30.3	3	12	
75-80	15	22.7	1	4	
>81	14	21.2	1	4	
Total	66	100	25	100	

Evaluation of the MNA and SARC-F scale administered to the subjects according to gender is provided in Table 5. While there was a statistically significant relationship between the SARC-F scores and gender (p=0.04), there was no relationship between the MNA scores and the same (p>0.05).

Table 5: Evaluation of the SARC-F and MNA Scores According to Gender

	Gender	N	Mean±SD	P
SARC-F Scale	Female	45	4.95±1.60	0.04*
	Male	46	4.22±1.75	
MNA	Female	45	22±3.09	0.82
	Male	46	22.15±3.22	

Relationship Between the Sarcopenia and Malnutrition Status of the Subjects

The subjects were divided into three groups according to the MNA score, i.e. normal, at risk of malnutrition and malnourished. As shown in Table 6, 59.3% of 91 subjects had risk of malnutrition, whereas 7.7% had malnutrition. In addition, 33% of the patients were normal in terms of malnutrition.

According to the SARC-F score, the subjects were divided into two groups: risk of sarcopenia and no risk of sarcopenia. It was found that 72.5% of the subjects had risk of sarcopenia, whereas 27.5% did not have the same.

Comparison of the MNA and SARC-F screening test results showed that, of the 66 subjects who had risk of sarcopenia according to the SARC-F test, 10.6% had malnutrition, 71.2% had risk of malnutrition and 18.2% had normal nutrition. There was a statistically significant relationship between the SARC-F and MNA screening test results (p=0.001).

Table 6: Evaluation of the Sarcopenia Status According to the Malnutrition Status of the Subjects

	No Risk of Sarcopenia N(%)	Risk of Sarcopenia N(%)	Total N(%)	P value
Normal Nutritional Status	18(72)	12(18.2)	30(33)	
At Risk of Malnutrition	7(28)	47(71.2)	54(59.3)	<0.001*
Malnourished	-	7(10.6)	7(7.7)	
Total	25(27.5)	66(72.5)	91(100)	

Evaluation of the Anthropometric Characteristics and Hand Grip Strength According to Gender
The evaluation of anthropometric measurements and hand grip strength according to gender showed that there was a statistically significant difference in terms of the mean body weight, height, fat-free mass, hand grip strength and finger grip strength, as shown in Table 7 (p<0.05).

Table 7: Evaluation of the Anthropometric Measurements and Hand Grip Strength According to Gender

N=91	Gender		N	Mean ±SD	P
Body weight (kg)	Female		44	64.1±12.9	0.04*
	Male		46	69.9±13.1	
Height (cm)	Female		44	16.43±6.38	<0.001*
	Male		46	17.89±8.18	
	Female			Male	
BMI (kg/m2)	n(%)			n(%)	
BMI<19	1(2.3)			2(4.3)	0.51
19<BMI<21	10(22.7)			10(21.7)	
21≤BMI<23	7(15.9)			3(6.5)	
BMI≥23	26(59.1)			31(67.4)	
Total	44(100)			46(100)	
	Gender		N	Mean ± SD	
Fat-free mass (kg)	Female		44	40.04 ±7.59	0.004*
	Male		46	45.58 ±9.80	
Fat mass (kg)	Female		44	24.18 ±9.39	0.7
	Male		46	23.45 ±8.43	
Hand grip strength (kg)	Female	45		18.77±9.48	0.02*
	Male	46		25.55±15.76	
Finger grip strength (kg)	Female	45		5.93±2.98	0.001*
	Male	46		8.91±5.17	
	Female			Male	
Arm circumference (cm)	n(%)			n(%)	
<21	2(4.5)			2(4.3)	0.53
21≤ arm circumference<22	6(13.6)			3(6.5)	
≥22	36(81.8)			41(89.1)	
Total	44(100)			46(100)	
	Female			Male	
Calf circumference (cm)	n(%)			n(%)	
<31	12(27.3)			5(10.9)	0.05*
≥31	32(72.7)			41(89.1)	
Total	44(100)			46(100)	

Evaluation of the relationship between anthropometric measurements and hand grip strength according to sarcopenia risk status showed that there was a statistically significant difference in terms of body weight, height, fat-free mass, hand grip strength and finger grip strength according to the sarcopenia risk status (Table 8) (p<0.05).

Table 8: Evaluation of the Relationship Between Anthropometric Measurements and Hand Grip Strength of the Subjects and Sarcopenia Risk Status

N=91	Risk of Sarcopenia n=66	No Risk of Sarcopenia n=25	P value
Variables	Mean±SD	Mean±SD	
Body weight (kg)	64.7±13.2	72.1±12.8	0.02*
Height (cm)	159.878±8.644	164.4±8.456	0.03*
BMI (kg/m2)	n(%)	n(%)	
BMI<19	3(4.5)	-	0.12
19≤BMI<21	15(22.7)	6(24)	
21≤BMI<23	10(15.2)	-	
BMI≥23	38(57.6)	19(76)	
Total	66(100)	25(100)	
	Mean±SD	Mean±SD	
Fat-free mass (kg)	40.969±8.355	47.472±9.77	0.002*
Fat mass (kg)	23.313±9.239	24.636±8.06	0.53
Hand grip strength (kg)	18.242±10.583	32.1±15.294	<0.001*
Finger grip strength (kg)	5.924±3.227	11.28±5.072	<0.001*
Arm circumference (cm)	n(%)	n(%)	
<21	4(6.1)	-	0.17
21≤ arm circumference<22	9(13.6)	1(4)	
≥22	53(80.3)	24(96)	
Total	66(100)	25(100)	
Calf circumference (cm)	n(%)	n(%)	
<31	17(25.8)	1(4)	0.02*
≥31	49(74.2)	24(96)	
Total	66(100)	25(100)	

Dıscussıon

The SARC-F scale translated to Spanish was used to evaluate sarcopenia in 487 participants 60 and older living in Mexico. Cronbach's Alpha was found to be 0.64 as a result of the study. This showed that the Spanish version of the SARC-F scale could be used reliably (Sz leif, 2016). In a cross-sectional study that aimed assess the reliability of the SARC-F scale in Japan, kappa coefficient of reliability was found to be 0.66 in 207 diabetic Japanese subjects aged 65 and older. This also showed that the SARC-F scale could be reliably used in Japan (Satoshi, 2016). The present study also provided similar results as other studies in the literature, wherein the Turkish version of the SARC-F scale was found to be valid and reliable.

4000 Chinese subjects aged 65 and older participated in a study that aimed to predict the negative outcomes of the SARC-F scale items. It was reported that the scale could be limited to 3 items by removing the rise from a chair and fall components (Woo, 2018). In the present study, it was found that the scale became more reliable with a Cronbach's Alpha of 0.78, when the falls components was removed. This was thought to stem from the fact that older adults may not accurately remember the answer to the question "how many times did you fall?" or that it was not clear whether sarcopenia was the cause or result of the fall since healthy subjects were included in the study, as seen in the study mentioned above.

In the Canadian National Health Research conducted by Garner et al. with 3,864 males and 4,745 females, it was reported that men included in the slightly overweight category had a higher quality of life since they had more muscle tissue, whereas the same did not apply to women (Graner, 2012). The present study also showed that women had higher risk of sarcopenia. This finding was thought to be associated with the increase in bone density reduction after menopause.

According to the results from the third phase of the EPIC-Norfolk research conducted between 2004 and 2011, grip strength and gait speed exhibited a decrease in parallel to advanced age (Keevil, 2013). Data from the study may suggest the presence of a significant relationship between sarcopenia and decreased gait speed and grip strength with advancing age. The present study also showed that there was a statistically significant relationship between age and sarcopenia (p<0.05).

A literature review showed that malnutrition could lead to sarcopenia. The relationship between malnutrition and sarcopenia scales was also significant in this study (p=0.001)

Anthropometric measurements of the body are of utmost importance in evaluating the condition of an individual, conducting risk analysis for and diagnosing various diseases and for the success of treatment. This subject is rapidly becoming more popular today, wherein there is a pursuit of highly reliable and valid, repeatable, easily applicable, inexpensive and accessible new methods and scales. Loss in the lower extremity muscles is more rapid as compared to the upper extremities in the elderly. Therefore, there are various studies indicating that calf circumference is an important predictor (Rolland, 2003). In a study by Bahat et al., 274 Turkish men aged 60 and older were evaluated and it was found that 10.5% of the participants had a calf circumference lower than 31 cm. According to the findings of the study, it was reported that older males in the Turkish population had higher rates of functional dependence, sarcopenia and malnutrition as compared to those living in developing and developed Western countries (Bahet, 2013). In another study conducted with 145 subjects aged between 18 and 83, it was found that the mean calf circumference was 37.2 ± 3.4 cm in females and 37.7 ± 5.2 cm in males (Ata, 2016). Kusaka et al. conducted a study with subjects aged between 65 and 86 and reported that it would be more sensible and suitable to define a wide calf circumference with non-sarcopenia (Kusaka, 2017). Results of another study conducted with 526 subjects aged between 40 and 89 indicated that calf circumference has a positive correlation with muscle mass and the optimal calf circumference cut-off value for predicting sarcopenia is <34 cm in men and <33 cm in women (Kawakami, 2015). In Turkey, the first study that aimed to investigate the risk of sarcopenia in the population was conducted by Akın et al. The study included 879 subjects older than 60 living in Kayseri. In the study, the rate of sarcopenia associated with muscle mass was evaluated using a calf circumference criterion of less than 31 cm and a mid-upper arm circumference criterion of less than 21.1 cm and 19.9 cm for males and females, respectively. The rate of sarcopenia according to calf circumference was 6.7% (7.7% in females and 5.6% in males), whereas the same according to mid-upper arm circumference was 7.3% (8.0% in females and 6.6% in males). In accordance with this data, it was concluded that sufficient muscle mass could not provide reliable use of muscles and that muscle function was a more important marker than muscle mass in the diagnosis of sarcopenia (Akın, 2015).

In the present study, 72.7% of females had a calf circumference of 31 cm and higher and 27.3% had a calf circumference less than 31 cm, whereas 89.1% of males had a calf circumference of 31 cm and higher and 10.9% had a calf circumference less than 31 cm. Accordingly, sarcopenia risk status was evaluated in association with calf circumference. It was found that 25.8% of those who had risk of sarcopenia had a calf circumference less than 31 cm, whereas 4% of those who did not have risk of sarcopenia had a calf circumference less than 31 cm. Majority of those who had risk of sarcopenia had a calf circumference higher than 31 cm. Evaluating according to the sarcopenia risk status, it was found that 25.8% of those who had risk of sarcopenia had a calf circumference less than 31 cm. In this study that employed a mid-upper arm circumference less than 21 cm as a criterion, 4.5% of females and 4.3% of males had an arm circumference less than 21 cm. According to the sarcopenia risk status, while 6.1% of the subjects who had risk of sarcopenia had an arm circumference less than 21 cm, none of those who did not have risk of sarcopenia had an arm circumference less than 21 cm. Arm circumference did not have a statistically significant relationship with sarcopenia risk status and gender (p>0.05).

Murphy et al. prospectively evaluated the appendicular fat-free mass and grip strength of 3075 individuals aged between 70-79 for seven times within 9 years. Fat-free mass of those included in the study was standardized with respect to height and calculated in kg/m2. The mean fat-free mass was found to be 6.52±1.14 kg/m2 in women and 40.9 ±8.53 kg/m2 in men. The mean BMI value was 27.7±5.50 kg/m2 and 27.0±3.90 kg/m2 in women and men, respectively. In addition, the mean age was 73.5±2.88 and 73.8±2.85 years in women and men, respectively. In the study, it was observed that the increase in age and BMI was a determinant of transition from a normal condition to sarcopenia (Murphy, 2014).

In a study by Akın et al., hand grip strengths were evaluated and it was found that the mean hand grip strength was 17.9 in females and 30.6 kg in males (Akın, 2015). In the Health and Retirement Study conducted with Americans by Haas et al., gait speed and grip strength were evaluated according to gender. The study included data from 14,493 individuals who were born before 1947. It was reported that gait speed and grip strength were higher in males as compared to females, regardless of age (Haas, 2012). In the present study, the mean hand grip strengths were 18.77±9.48 and 25.55±15.76 kg in females and males, respectively. Evaluating hand grip strength according to the sarcopenia risk status, it was found that the subjects who had risk of sarcopenia had a mean hand grip strength of 18.24± 10.58 kg, whereas the same was 32.1±15.29 kg in those who did not have risk of sarcopenia. In the present study, hand and finger grip strength had a significant relationship with gender and risk of sarcopenia (p<0.05).

Although there is a large amount of data on the relationship between BMI and sarcopenia in the literature, a significant relationship between the two was not observed in the present study (p>0.05). There was a significant relationship between body weight, height, fat-free mass, hand-finger grip strength and sarcopenia risk status (p<0.05).

Tanimoto et al. aimed to investigate the effects of sarcopenia on falls in a study that they measured grip strength with a hand dynamometer and muscle mass with BIA in 1110 Japanese subjects 65 and older. Of the subjects who participated in the study, 14.9% of females and 13.4% of males were found to have sarcopenia. The prevalence of falls was 21.3% among females and 16.9% among males. The study showed that history of falls was significantly more prevalent among those who had sarcopenia and those who had reduced grip strength and gait speed than those who did not. However, it could not be clarified whether sarcopenia and reduced gait speed and grip strength were the cause or result of falls, since the study was cross-sectional and included healthy individuals (Tanimoto, 2014). It was thought that the increased reliability coefficient as a result of removing the falls component was also due to the same reason in the present study.

In conclusion, it is thought that the SARC-F scale, which can be used in the early diagnosis of sarcopenia, will be beneficial in maintaining good health and increasing quality of life.

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TRACKING BUSINESS INTELLIGENCE RESEARCH TRENDS:
A BIBLIOMETRIC APPROACH

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ABSTRACT
Business intelligence is considered as a fundamental necessity for any type of organization. The field of business intelligence has shown continuous enhancements and has kept pace with rapidly changing business environments. The purpose of this study is to explore research trends in scientific articles pertaining to business intelligence. The data set was extracted from the Web of Science and bibliometric method was used to analyze keywords. After the identification of research trends based on frequency, co-occurrence analysis was used to construct and visualize a bibliometric network. The results comprise twenty-nine research trends and four visualizations of the network based on frequency of occurrences, average publication year and densities. Practitioners and scholars may benefit from this study to gain an understanding of the past research in business intelligence field.
Keywords: Bibliometric Network, Business Intelligence, Research Trend

Introduction
Business intelligence has a pivotal role in each organization, as it can accomplish various tasks including collecting, storing, analyzing and spreading data. It is valued as a top technology investment in Europe and considered as an important factor to assist organizations in gaining competitive advantage (Derksen & Luftman, 2014; Miller et al., 2006).

Business intelligence has a history of approximately 60 years since it was first mentioned by Hans Peter Luhn (Luhn, 1958). It is premised that the evolution of business intelligence has received support from concepts and developments of management information systems (Rodrigues, 2002). The studies of Scott Morton (1967) and Gerrity (1971) investigated the connection of business intelligence with decision support systems and chronologically by time lastly, it is claimed that enterprise information systems have influenced developments in business intelligence field (Arnott & Pervan, 2005).

According to Pirttimäki (2007), it is difficult to reach a universal definition for business intelligence. However, some studies define it in the line of transforming data to information and then knowledge (Vizgaitytė & Skyrius, 2012; Stylianou et al., 2013). The definition of Vercellis (2009) was used as the base for this study and it is stated: "set of mathematical models and analysis methodologies that exploits the available data to generate information and knowledge useful for complex decision making processes".

As claimed by Parker, Benson and Trainor (1988) classical analyzing techniques of cost-benefit are not the most proper ones for evaluation of investments in information technology. A shift in paradigm for evaluation techniques of information technologies was represented by Saaty (1998) and which gives more importance to issues different than financial such as intangibles.

Previous similar studies have conducted bibliometric methodology in various approaches such as the most productive nations or cities, distribution of research areas and publications, the most influential publications and trends in online databases (Chen et al., 2012; Liang & Liu, 2018; López-Robles et al., 2019; Wyskwarski, 2019; Zou et al., 2019). This study differs from others because it adopts an approach based on basic technological elements of business intelligence. Haustein & Larivière (2015) conclude that tracking of trends is indispensable for understanding the research landscape of any field.

The Study
Quantitative approach and bibliometrics method were adopted for the purpose of this study to identify research trends in scientific articles related to the business intelligence. As stated by Liang and Liu (2018) bibliometrics comprises statistical and quantitative analysis of texts and authors based on frequency, centrality and connection. Despite descriptive statistics, network analyses such as co-word, co-occurrence, co-citation, co-authorship or citation may be used to explore publication trends, impacts of a subject, impact of an academic output, authors network or citation patterns (Liang & Liu, 2018). In this research the focus were the texts composed of keywords, which were analyzed by descriptive statistics based on high frequency and bibliometric network visualization based on co-occurrence links.

The data set was retrieved from the Web of Science Core Collection database. The sample and target population were extracted from the population by applying the purposeful sampling. Creswell (2012) listed reasons like convenience, presence and availability of certain characteristics of participants as cause why researches choose non probability sampling for selecting the sample (Creswell, 2012). The population included 7664 academic outputs that have "business intelligence" terms in all possible searchable fields, all available science citation indexes, all languages and time span from 1945 to 2019. The 1727 academic outputs part of target population extracted from population own these characteristics: scientific articles, Science Citation Index Expanded (SCI-EXPANDED), Social Sciences Citation Index (SSCI), Arts & Humanities Citation Index (A&HCI), Emerging Sources Citation Index (ESCI) and English language. The final stage of purposeful sampling consisted in extracting 198 scientific articles from target population. The scientific articles own the characteristics of target population and at least one of basic technological elements terms combined with "business intelligence" terms in all possible searchable fields. In their study Rikhardsson and Yigitbasioglu (2018) have outlined that the major vendors ((*Gartner, 2017. Magic Quadrant for Business Intelligence and Analytics Platforms*, n.d.; Elliot & Woodward, 2015; Howson & Arnold, 2013; Troyansky et al., 2015; Volitich & Ruppert, 2012) and academic literature (Chae & Olson, 2013; Chaudhuri et al., 2011; C Howson, 2013; Cindi Howson, 2007; Sheikh, 2013) identify data analyses, data management, infrastructure and information delivery as basic technological elements of business intelligence and analytics. The set of rules of Web of Science for issues like grammar, synonyms, lemmatization and stemming are taken into consideration for all search queries (*Web of Science Core Collection Help*, n.d.). The Figure 1 represents the search queries of population, target population and sample.

Figure 1: The Search Queries for Population, Target Population and Sample

ALL=("business intelligence") *Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI Timespan=1945-2019*	Population
(ALL=("business intelligence")) *AND* **LANGUAGE**: (English) *AND* **DOCUMENT TYPES**: (Article) *Indexes=SCI-EXPANDED, SSCI, A&HCI Timespan=1945-2019*	Target Population
((ALL=(("business intelligence") AND ("data management"OR"data analyses"OR"data analysis"OR"information delivery"OR"information deliveries"OR"infrastructure"OR"infrastructures")))) *AND* **LANGUAGE**: (English) *AND* **DOCUMENT TYPES**: (Article) *Indexes=SCI-EXPANDED, SSCI, A&HCI Timespan=1945-2019*	Sample

In order to analyze the data set of sample VOSviewer 1.6.13 software tool and co-occurrence analysis were used to construct and visualize bibliometric network of keywords. Compared to other computer programs that serve for bibliometric mapping, VOSviewer graphical representation is considered as more advanced (Van Eck & Waltman, 2010).

Initially, the bibliometric network was constructed that means places of items and links with each other are determined. Items may obtain various attributes in VOSviewer and some of which are weight, score and cluster number attributes (Van Eck & Waltman, 2019). In accordance with data set and research aim of this study and among other custom weight attributes, occurrences attribute was selected. The data set of sample amounts to 1115 keywords in total from author keywords or keywords plus of scientific articles. The keywords with at least 5 occurrences (by default value) and the highest occurrences are selected by VOS text mining methodology that performs part-of-speech tagging and calculation of distributions (Van Eck & Waltman, 2016). With regard to standard weight attributes, link strength represents the number of scientific articles where two keywords have co-occurred and total link strength represents total number of scientific articles where a keyword has co-occurred with other keywords of the network. The strength of links between items in a network gained from co-occurrence analysis depends on the counting method applied (Perianes-Rodriguez et al., 2016) and in this study full counting was applied to construct the bibliometric network. Average publication year score attribute was selected and its values for each keyword indicated colors of respective items in overlay visualization. Cluster number attribute represents the number of the cluster where each keyword belongs, based on the calculations of VOS unified mapping and clustering technique (Van Eck et al., 2010).

The steps that follow network construction are listed in this order normalization, mapping, clustering and visualizing. In pursuance of normalizing the differences between items of the network, VOSviewer applies association strength. The calculations of association strength deploy the numbers of links of each item, links between two items and all links in the network (Waltman et al., 2010). The unified approach of mapping and clustering executes the logic that the higher similarity between items the smaller distance and based on overall calculations and resolution parameter locates items into clusters(Van Eck & Waltman, 2010, 2014).

Networks can be illustrated with three different types of visualizations in VOSviewer software tool. Network visualization presents the items based on custom and standard weight attributes which respectively indicate the size of labels and circles and the thickness of lines. The color of an item in network visualization depends on the cluster where it belongs, each cluster has a different color. Related to label and circle size, thickness of lines and

distance between items, network visualization and overlay visualization are undifferentiated. Each overlay visualization is accompanied by a color bar which range the spectrum of colors from lower to higher score value. Density visualization is divided into two subtypes item and cluster, which follow the same calculations but they differentiate in the concept of neighborhood. Item density visualization considers as neighborhood all the items around the referred item while cluster density visualization considers as neighborhood all the items around and that belong to the same cluster with the referred item. Each item density is calculated based on kernel width parameter, items number and weight in the neighborhood and weight of item itself. The color of an item in density visualization changes from prominent to pale as item density decreases (Van Eck & Waltman, 2019).

Findings
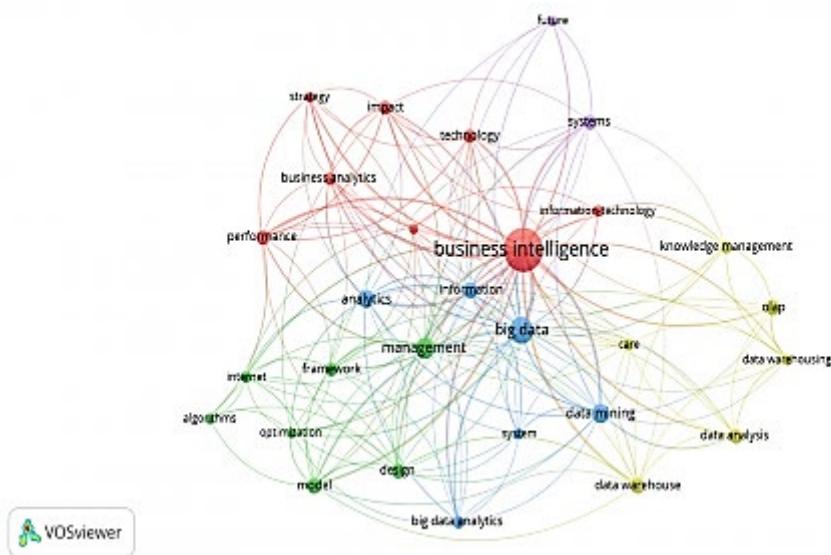
The high frequency of a keyword is a crucial point in this study because it indicates the prominence given by research to a particular topic (keyword). The keywords with high frequency of occurrences can be called research trends. The results, obtained from usage of VOSviewer text mining technique and descriptive statistics in order to select the keywords with the highest frequencies of occurrences, are presented in Table 1. The keywords in Table 1 are listed in descending order.

Table 1: Frequency of Occurrences of Keywords

| Item	Occurrences
business intelligence	74
big data	28
management	18
data mining	15
analytics	13
olap	11
model	11
information	10
data warehouse	10
systems	9
performance	9
design	9
data analysis	9
technology	8
impact	8
framework	8
knowledge management	7
business analytics	7
big data analytics	7
system	6
internet	6
information-technology	6
data warehousing	6
care	6
strategy	5
optimization	5
future	5
cloud computing	5
algorithms	5
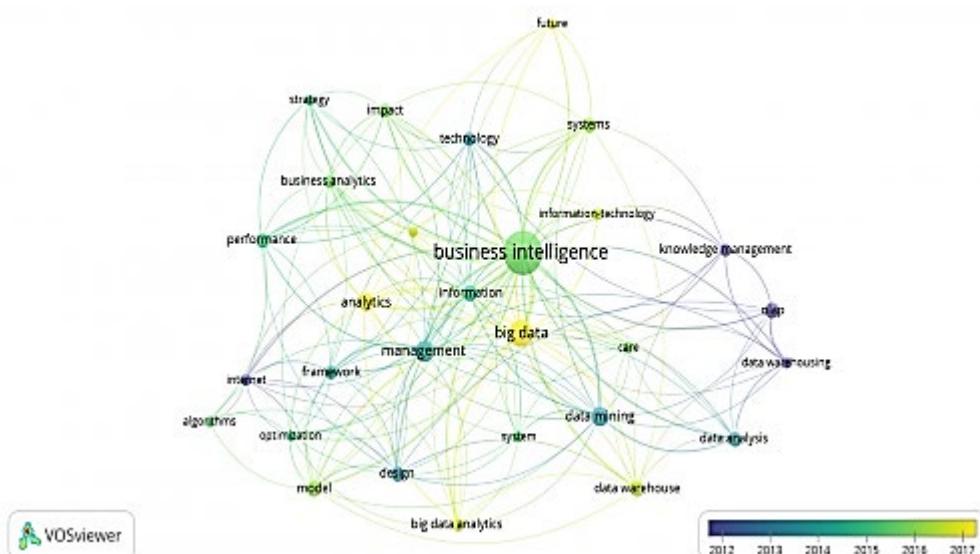
Network visualization of this study, which is illustrated in Figure 2, has 29 items (keywords) connected with each other by 178 links with an overall link strength of 374 and divided into 5 clusters. The keywords, which fulfill the condition that the frequency of occurrences (of a keyword) is equal to or higher than the minimum default value of occurrences, are part of the bibliometric network as items. Network visualization illustrate the items(keywords) in the way that the smaller the distance between two items means higher relevance to each other in terms of co-occurrence links; the thicker the lines between two items means the higher number of scientific articles where two keywords have co-occurred; the bigger the size of label and circle means higher frequency of occurrences of a particular keyword. The range of colors in network visualization reveal the number of clusters and the higher the resolution parameter the higher the number of clusters.

Figure 2: Network Visualization

In the overlay visualization illustrated in Figure 3, the size of labels and circles of items, the thickness of the lines that connect them and distance in between are exactly the same as network visualization in Figure 2. Score attribute range between 2009 and 2017 related to the average publication year of each item (keyword). The color of circles and lines change from blue to green and then yellow as the average publication year increases.

Figure 3: Overlay Visualization

Density visualizations were illustrated based on each item density which was calculated with kernel width parameter of 1.2. In Figure 4 item density visualization is presented and where the density of an item relies on all the items around it. In Figure 5 cluster density visualization is presented and where the density of an item relies on the items around that are also part of the same cluster. In both visualizations the color of items changes from pale to prominent as item density increases.

Figure 4: Item Density Visualization
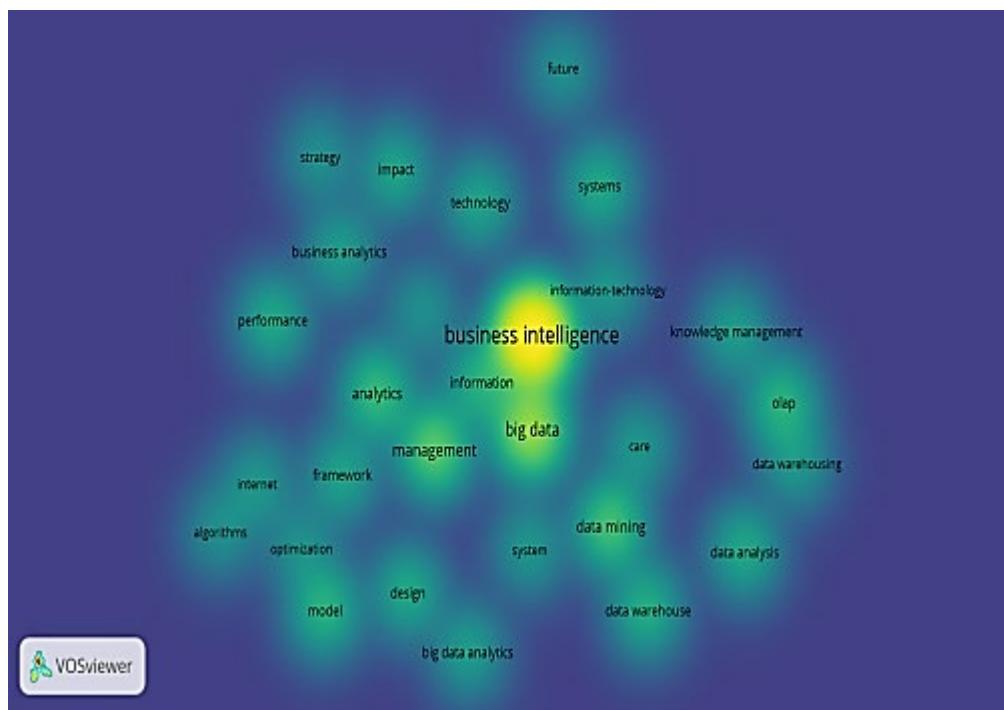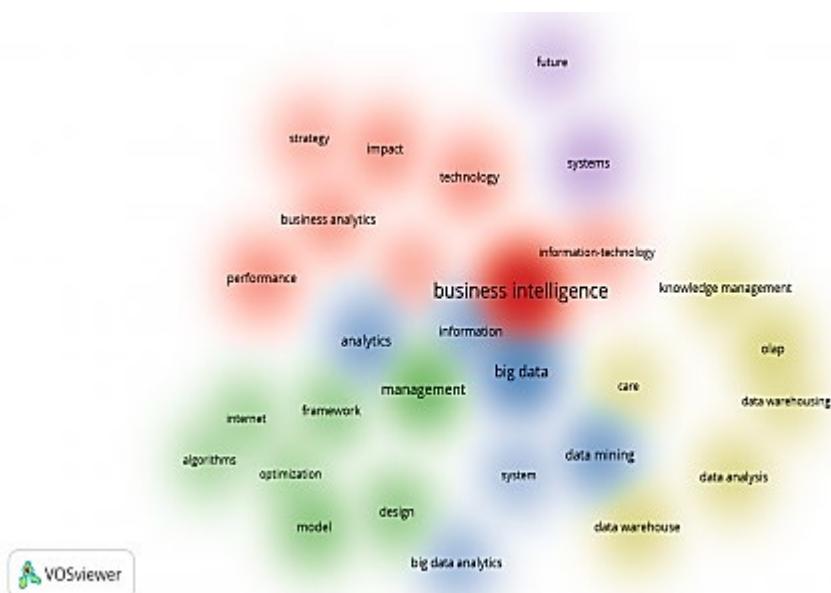
Figure 5: Cluster Density Visualization

Conclusion and Suggestions

Business intelligence is evaluated as an emerging field (Derksen & Luftman, 2014; Miller et al., 2006). Thus the tracking of its research trends may be essential because it provides insights into the list of sub-fields that has gained

more attention. This study employed bibliometric approach and co-occurrence analysis associated with scientific articles to explore research trends and co-occurrence links between them. The results consist of 29 research trends which are connected by 178 co-occurrence links with an overall link strength of 374. The research trends are separated into 5 clusters and illustrated in network, overlay, item density and cluster density visualizations, the colors of which are indicated respectively by cluster parameter, average publication year item density and kernel width parameter. The aim of this research was fulfilled because the results of analysis are all terms related to the business intelligence field. The first research trend ranked in terms of frequency of occurrences is business intelligence, followed by big data and management. The other research trends don't have big difference among each other in terms of frequency of occurrences and they are sorted from highest to lowest based on their frequency of occurrences are as follows: data mining, analytics, olap, model, information, data warehouse, systems, performance, design, data analysis, technology, impact, framework, knowledge management, business analytics, big data analytics, system, internet, information-technology, data warehousing, care, strategy, optimization, future. Both scholars and practitioners may benefit from this study in order to understand trends up to now and can plan their future research questions based on the trends in the business intelligence field.

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