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Review Paper

Ergonomics on the Context of Sustainability: A New Approach on Quality of Life

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Abstract
Ergonomics as a multidisciplinary science is known as a human centered science that is concerned with human beings and their quality of life. In this regard, the integration between ergonomics and the concept of sustainability might culminate in higher levels of quality of life. In terms of research methodology, this article is a review, and the main research question is to figure out the relationship between ergonomics and sustainability towards develop a new synergetic paradigm between these two mentioned fields. In this review article, we assessed some of the recent and related articles in which both ergonomics and sustainability were considered. This review aims to develop an integrated state-of-the-art approach including the benefits of both fields. PubMed and EBSCO were the databases consulted and the keywords of "ergonomics", "sustainability", and "product design" were selected to gather the relevant papers. Papers in English, which were published during last decade and that includes the keywords, were our inclusion criteria. Exclusion criteria were: microeconomics and cost-benefit studies, aspects of law in environmental issues, and technical issues in environmental protection (such as waste-water treatment, air pollution, etc.). We initially identified 255 papers. This was narrowed down to 33 articles that addressed issues. In a critical review of the abstracts and full papers, 9 papers remained for the final assessment. Of these papers, 64% were from a management approach. Three articles had product design approach. Most of the assessed issues were about ergoecology, business management, s system-based approach, global supply chains, design for sustainability, and a cost-effective approach. Based on the mentioned articles, it seems that introducing a new term that includes all the positive aspects of ergonomics and the sustainability scope, is unavoidable. Therefore, we propose a new approach that includes the majority aspects of ergonomics, sustainability, and design. This new paradigm helps the related experts to manage a better future life for all.

Keywords: *Ergonomics, Sustainability, Quality of life, Human being, Health promotion.*

INTRODUCTION

Quality of life (QoL) is one of the main concerns of governments, economists, hygienists, municipalities, and social policymakers and authorities [1- 3]. Besides, QoL is known as one of the main indicators of sustainability [4- 6]. QoL is also one of the prominent approaches of the 17 targets of new approach on sustainable development goals [1]. Brundtland commission entitled "Our Common Future" [7] opened the gate towards quality of life throughout sustainable development [6]. The significance of environmental protection, green economics, and quality of life is considered by social authorities, urban planners, health organizations and also economics associations [8-10]. Promotion in QoL and sustainability is important not only for general life style but also for industrial sectors and organization [4]. Sustainability is growing day to day, and sustainability evolution needs some systemic changes and also some structural improvement [11], also the product design and development related studies have some ignorance three main pillars of sustainability. Besides, ergonomics scope and discipline also require some evolutions, in this regards making a synergy between two mentioned firms will be ended to a more appropriate and effective way to achieve quality of life for all and this is the main objective of this review in which the authors conducted to figure out the new approach towards the quality of life, based on both scope of sustainability and ergonomics. To achieve higher levels of quality of life whether in developing or developed countries, making and implementation appropriated process and systems are expected. In this regards, effective utilization of new multidisciplinary scientific paradigm might be considered

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to improve the quality of life. Moreover, majority of our life style is related to use products; in this regards ergonomics and sustainable products play a critical role in our life.

Undoubtedly ergonomics as a multidisciplinary science, product design as daily needs of human, and sustainability as a context, concerned with the human being, healthy life and environmental protection. Furthermore, in spite of some current approaches on ergonomics and sustainability, such as Ergoecology [12], human factors engineering (HFE), Sustainability and green ergonomics[13-14]; more study and research about the role of ergonomics in sustainability needs to fill the some probably knowledge gaps. Additionally, relation between aspects of product design and ergonomics and sustainability is not also so clear, therefore, the authors decided to figure out some related issues throughout a review article.

In this work, according to the review of several sorts of reports and papers, we developed a new integrated approach consistent with all benefits of ergonomics and sustainability especially in the field of product design. Furthermore, to develop a better view of this new approach ergonomics and sustainability in both aspects of production and product design were focused. In fact, the pros and cons of current published papers and studies in terms of interconnection of ergonomics and sustainability were considered. Also, it should be mentioned that the terms of 'sustainability' and 'sustainable development (SD)' which are often used interchangeably, are not the same and in this work we emphasized on 'sustainability' more than 'sustainable development'.

SUSTAINABILITY CONCEPTS

Sustainability which is known as a global pledge is not a new term. According to [13-14], Carlowitz (1713) used the word of sustainability to explain the significance of the natural resources.

Sustainability concepts and sustainable development are so important terms for academic researchers [5, 15], business managers and product development authorities [16-17], community safety experts [17] and so on.

United Nations as an intergovernmental organization and also another related organization such as the South Pacific Applied Geosciences Commission emphasize on the sustainability goals and developing the related indicators. Developing related indicators for sustainability measurement is considering during the past two decades [19].

The concept of sustainability covers three main aspects of social, economic and ecological in which to make a balance between the mentioned scopes are considered [20-22]. Undoubtedly, pillars of sustainability have covers some different and vast scope per se. The firm of production and product design has an associate with the sustainability. Sustainable development is known as an appropriated context towards the quality of life [4-6]. Furthermore, daily products have an important role in our life, and product design process is also associated with all three aspects of sustainability (Fig. 1)

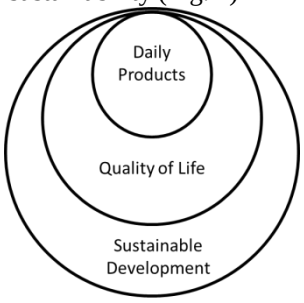

Fig 1. The scope of sustainability-related products

The role of products in our life style is related to materials, meeting the human requirements, environmental considerations and so on. Also considering with the importance of production and life, there are a lot of recent research about life cycle assessment of products [23-24], therefore there is a firm association between products characteristics and sustainability concepts.

ERGONOMICS

One of the multidisciplinary sciences which may help to urban planners, managers, social authorities, health organizations and designers in terms of quality of life and sustainable development is Ergonomics. However this field of science in comparison with other knowledge seems a bit new, but during some decades, development of ergonomics scope has been substantial. This multidisciplinary science has a wide scope in which human being and design for human needs and requirements are known as the main aims [15, 25-27].

Ergonomics is a multidisciplinary science which concerns about fitting the job to the operators and fitting products to users' demand to make them more efficient, productive, safer and satisfied [28-29].

Ergonomics has dual goals of health promotion and productivity and considers human health and human performance, simultaneously [30]. Ergonomics has a vast field in which there are five sub-branches of micro-ergonomics, macro-ergonomics, cognitive, environmental and social ergonomics (Fig.2).

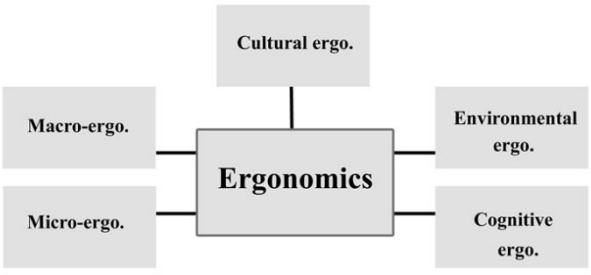

Fig 2 The scope of Ergonomics

Environmental and social ergonomics aspects are associated with sustainable development concept. Additionally, some new approaches in ergonomics scope have been introducing such as Ergoecology which is based on the sustainability, anthropocentric approach, and the

systemic focus [31]. According to the wide scope of ergonomics, there are altered domains which might be related to ergonomics from health science to product design, and from physical activities and somatic disorders to mentality [29]. In this regards, engineering fields, social science, psychology, design and art are related to ergonomics, as well.

As ergonomics is a human center science and considering the significance of environmental health for the human being, it is supposed to the ergonomics concerns sustainability, as well.

User center design as one of the ergonomics approaches contributes to lifestyle improvement through design for human activities and behavior. Moreover, Ergonomics has a prominent role in design culture and also design for culture. The themes which are involved in cultural-social ergonomics show the significance ergonomics place in social aspects of sustainability. Ergonomic design processes emphasize to meet human needs in both levels of individuals and the community, in this regards the ergonomic considerations should be emphasized on product design process.

PRODUCT DESIGN

One of the main approach and expertise of industrial designers is product design. Industrial design students have some courses which are related to this review scope such as ergonomics and also introduction of materials. In the ergonomics courses, some parts of ergonomics such as micro-ergonomics, environmental and cognitive ergonomics would be covered, and in the course of materials, they learn about the materials and their applied in product During last decades, the knowledge of people about usability of product and inclusive design are evaluated, in this regards different aspects of product design and process of manufacturing might be consider by end users [32]. Furthermore, our resources are limit and there are some sorts of critical environmental impacts [33], in which the role of materials is highlighted, in this regards the place of designers are also prominent. However, the linkage between materials and ergonomics and also sustainability aspects of design is a bit intangible. In this regards, in this review the authors conducted to point on product design as a keyword and also ergonomics and sustainability and figure out the relationship between these areas.

METHOD

This review article focused on the relationship between ergonomics and sustainability and aimed to develop an integrated state-of-art approach including all benefits of both mentioned fields. This new approach is supposed to play a critical role in the quality of life. In this research, we reviewed the literature on sustainable development and ergonomics by using PubMed and EBSCO. For gathering the related articles and information through the mentioned search engines, the keywords "ergonomics", "sustainability", and "product design" were preferred.

We initially identified 255 papers in English which were published in last 10 years. To have appropriated papers selection, the inclusion criteria were: ergonomics, sustainable development, and product design.

Exclusion criteria were: microeconomics and cost-benefit studies, aspects of law in environmental issues, technical issues in environmental protection such as waste water treatment, air pollution and so on. Likewise, the aspect of human-computer interaction which is related to human factors engineering was excluded.

By the mentioned criteria, 33 papers were chosen based on their titles (30 in EBSCO, and 4 in PubMed), in which one of the PubMed paper was removed as it was a review. After the abstracts reading, 18 papers in EBSCO, and two in PubMed were selected to full-texts assessing. Then, according to a critical review of the papers' full texts and excluding the unrelated papers, 9 papers remained to final assessment. Figure 3 shows the papers' screening process.

All of the articles were also searched during May 2017.

RESULTS

In this review, nine articles were assessed in terms of their objectives, theme, results and followed approach. We categorized these papers into two approaches of "management" and "product design" based on their contexts. 7 out of 9 papers consisted of management approach, and 3 ones have product design approach, of course, one out of 9 articles includes both the mentioned approaches. 64% of these studies typically were in management approach and 2 out of 3 papers with design approach which were studied in the USA. All of the selected papers were published during 2012 till 2016 in the USA, Brazil and some European countries i.e., Italy, Germany, Denmark and Serbia (Table 1).

More information about the articles is as follows:

Gabriel García-Acosta Et.Al (2016), (paper No.3, Table 1) emphasized on ergoecology. They believe that man-machine approach is related to the built environment in which the human being has a key role. In this paper PESTE factors introduced which including the five factors related to human and system's surroundings. PESTE stands for a systems surroundings consists of political-legal (*P-L*), economic-financial (*E-F*), social-cultural (*S-C*), technological-scientific (*T-C*), and ecological-geographical (*E-G*) [12].

Sonja Pavlovic-Veselinovic (2014) in her paper (paper No.9, Table 1) emphasized on the role of ergonomics in sustainability. In this paper, ergonomics as a systemic, interdisciplinary, multidisciplinary and applied science was underlined. Ergonomics is related to the overall environment to humans' characteristics i.e., psychophysiological capabilities and limitations, and also anatomy and psychology. Ergonomics is focusing on safety, health and quality of life. This multidisciplinary science concerns with work efficiency and productivity, as well. Based on the mentioned scope, ergonomic design has an association with the whole environment [34].

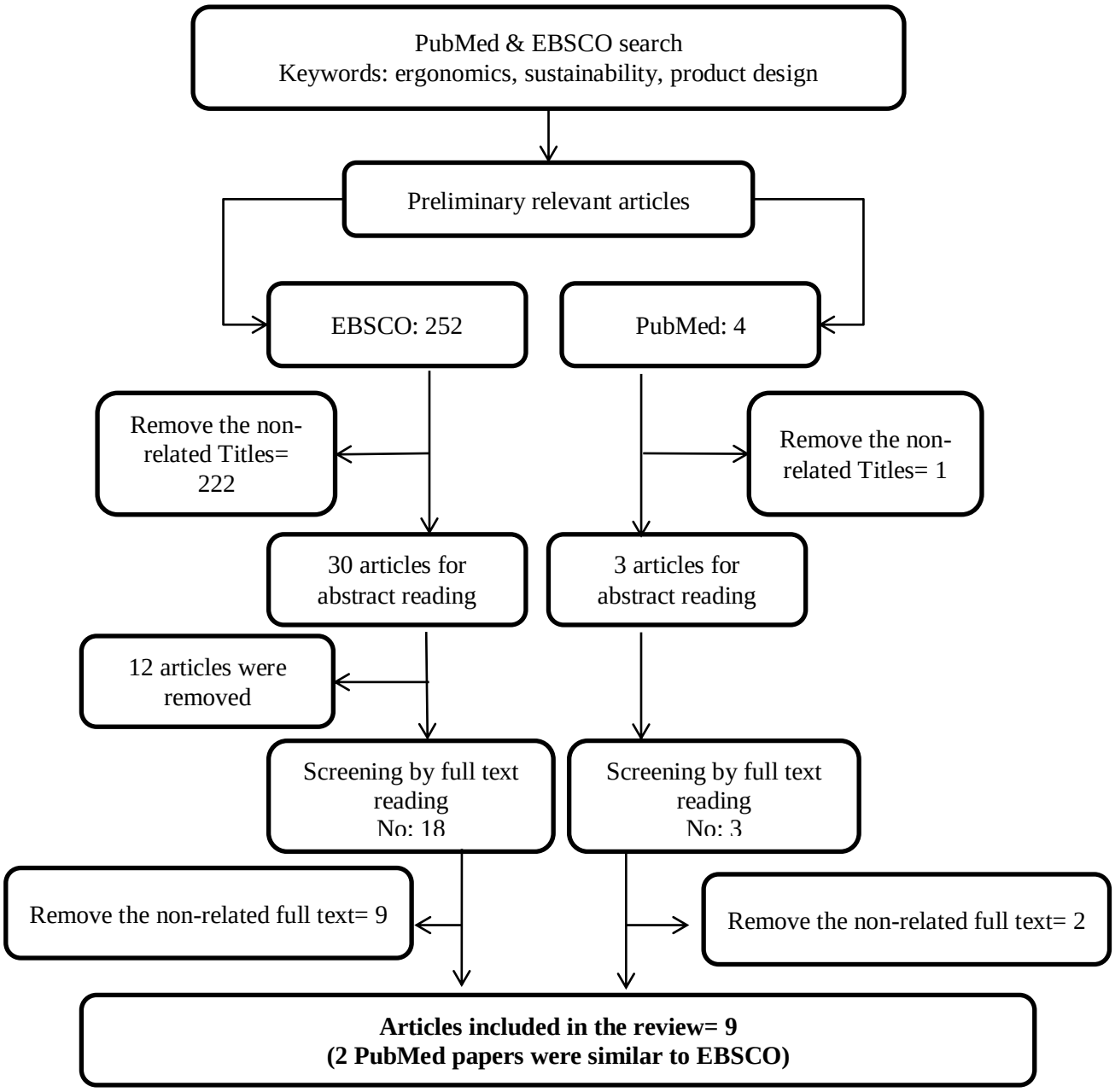

Fig 3. The papers' screening hierarchy

Klaus J. Zink & Klaus Fischer (2013) in their paper (paper No.7, Table 1) was introduced the concept of sustainability as a new approach in human factors and ergonomics [35]. They mentioned that both of ergonomics and sustainability are the wide system including some similar scope. The interaction between ergonomics and sustainability paradigm, and necessity of sustainability in ergonomics as a new approach focused in their paper.

Mario Cesar Vidal et.al (2012) (paper No.8, Table 1) concern with the relationship between ergonomics and business world, and operational engineering. They believe that ergonomics should be more involved in business management scope. In this regards, they mentioned that by Ergonomic Maturity Model (EMM) association of ergonomics and sustainability scope might be done. They also emphasized on the necessity of ergonomics involvement in managing the process, project and permanence [36].

Hasle et.al. (2012) in their paper (paper No.6, Table 1) mentioned about the relationship between global supply chain and sustainability, then pointed to the role of ergonomics in this relationship, as well [37].

They believe that strategies in human factors engineering and ergonomics help to production units involved in supply chains. This shows that there are some challenges on the role of sustainable ergonomics in the supply chain, in this regards, the integrated effects of micro and macro ergonomics was considered [ibid].

Francesca Tosi (2012) in his paper (paper No.2, Table 1) studied about the key role of ergonomic design is the context of sustainability. He mentioned the effectiveness of ergonomics strategy in the process of design for sustainability and pointed on some industrial

design projects which show the role ergonomics in sustainability, such as an Ergonomics and Ecology in the kitchen design and also a comfort bike design. These sorts of samples also show the role of ergonomics strategies in product development. Besides, he shows that the role of ergonomics in the field cultural based design [38].

The six above mentioned papers, mostly have a point of view on management approach about ergonomics and sustainability relationship. However, the three papers as follows have the theme of the design approach.

Pilczuk, D., and Barefield.K. (2014) showed (paper No.1, Table 1) that employees' engagement increase in both programs of sustainability and ergonomics by ergonomics interventions. In this case study, the green ergonomics was introduced as a key factor towards sustainable development, too. The studied case also was a footrest design for office workers, in which the cost-effective ergonomic solutions were emphasized [39].

Nadadur. G. and Parkinson (2013) showed that anthropometric design could help to make a sustainable workplace (paper No.5, Table 1). This paper explains that ergonomic design throughout anthropometry is related to all aspects of sustainability, in which reducing the raw material also achieved [40].

Giuseppe A., et.al. (2012) studied about elderly in an environmental sustainable (paper No.4, Table 1), and in this case, they showed that the effectiveness of ergonomic design towards sustainability [41]. In this paper, the role of Information and communication information (ICT) on life easier and safer for vulnerable groups was emphasized, as well.

Based on the reviewed articles and considering with the main context and themes of the articles, we extracted the Table 2 in which 9 scopes are highlighted, and including the authors' approaches.

Table 1. The articles' characteristics

No	Author(s)	Location	Title	Methods	Results	Conclusion
1	Davana Pilczuk, and Kevin Barefield	USA	Green ergonomics: Combining sustainability and ergonomics	In this case study, combination of ergonomics and sustainability was followed throughout assessment of foot rest among employees at Gulfstream Aerospace Corporation (GAC)	Results show that the effectiveness of ergonomic intervention throughout the footrest design was ended to cost-benefit aspects and saving money, as well.	Green ergonomics projects, as a new approach on ergonomics and sustainability helps manufacturing companies to reduce work-related disorders, and also getting better in terms of cost-benefit approaches.
2	Francesca Tosi-20122014	Italy	Ergonomics and sustainability in the design of everyday use products	In this case study, two different product design were analyzed in which the products' comfortability was focused.	In this paper shows that ergonomics plays a critical role in innovative design approaches considering with a wide scope of ergonomics.	-In this paper the author emphasizes on applications of ergonomics theory and issues in the companies. - The lack of Ergonomics structures produces a break in the program sequences of systems so make a negative impact on management process, as well.I t means that Ergonomics should be involved with process, project and permanence.

No	Author(s)	Location	Title	Methods	Results	Conclusion
3	Gabriel García-Acosta. Et.al 2014	Colombia	Ergoecology: fundamentals of a new multidisciplinary field	In this paper ergoecology as a new multidisciplinary area was considered and human ecology also was focused	In this paper shows that ergonomics plays a critical role in innovative design approaches considering with a wide scope of ergonomics.	-In this paper the author emphasizes on applications of ergonomics theory and issues in the companies. - The lack of Ergonomics structures produces a break in the program sequences of systems so make a negative impact on management process, as well. I t means that Ergonomics should be involved with process, project and permanence.
4	Giuseppe Andreonia. et al. 2012	Italy	Ergonomics and design for sustainability in healthcare: ambient assisted living and the social-environmental impact of patients lifestyle	The sample research project in this paper was Babylandia (a project for the promotion of Lombardy) in which the kids' products were assessed. This assessment and prototyping focused on ergonomic design, too. Samples in this research consisted of pupils of kindergarten	The results showed that usability and pleasure among pupils in the interaction with the objects considered.	This research shows that Ergonomics and Design in the healthcare field make a useful condition to achieve sustainability. Association between ergonomic design and ICT also create efficient circumstances.
5	Gopal Nadadur & Matthew B. Parkinson 2013	USA	The role of anthropometry in designing for sustainability	In this paper anthropometric design is introduced as a way to achieve sustainability and following these three goals based on design for sustainability (DFS): reducing raw material consumption, increasing usage Lifetimes and ethical human resource considerations. The design specifications and relevant anthropometry that play a role in this	This study showed that by seat design based on anthropometric data and related percentiles calculation, changing the seat pan depth and width size to less than current situation (case studies) raw material might be decreased, too.	This case study shows that there are some associations between ergonomics design and design for sustainability. Also the case studies in this reports show that anthropometric design based on the valid body size data help to designers to prepare appropriated designs. Besides according to these

No	Author(s)	Location	Title	Methods	Results	Conclusion
				case study. Besides, the application of anthropometry synthesis, virtual fitting, and sizing and adjustability allocation methods in the design of an industrial workstation were considered		sorts of data, designers recognize the importance of human variability.
6	Haslea, Peter and Jensen, Per Langa 2012	Denmark	Ergonomics and sustainability – challenges from global supply chains	In this study the relationship between ergonomics and global supply chains which are related to sustainability, was considered.	In this study five challenges of global supply chains which are associated with sustainability were introduced including: (1) social aspect of sustainability, (2) the key performance indicators and its role in the supply chains management (3) the constant changes in supply chains, (4) the challenge in establishing participation, and (5) the development of agency and regulatory mechanisms.	Based on the findings and five challenges which are related to both ergonomics and sustainability aspects, it seems that the role of macro-ergonomics is critical, however, micro-ergonomics is also important. Ergonomics may have positive effects on marketing as well.
7	Klaus J. Zink & Klaus Fischer 2013	Germany	Do we need sustainability as a new approach in human factors and ergonomics?	The interaction between ergonomics and sustainability paradigm, and necessity of sustainability in ergonomics as a new approach focused in this paper. In this descriptive study some of the main definitions of Ergonomics from German Human Factors and Ergonomics Society (Gesellschaft fur Arbeitswissenschaft, GfA 1999), IEA and so on considered. Furthermore the sustainability	According to assess the scope of ergonomics and sustainability, there are several common issues and goals in these two disciplines.	Based on the assessment of ergonomics and sustainability issues it seems that the concept of sustainability as a totally new approach in human factors and ergonomics is not necessarily needed I t means that these two disciplines have a common goals with a bit different methods.

No	Author(s)	Location	Title	Methods	Results	Conclusion
				definition and scope also focused.		
8	Mario Cesar Vidala et.al., 2012	Brazil	Ergonomic sustainability based on the ergonomic maturity level measurement1	The chosen method was based on Ergonomics Maturity Matrix (EMM) which includes four the following sections: 1-choice of representative cases; 2-pre evaluation of maturity level using the primary scale 3-building a secondary scale (taxonomy of experienced troubles) 4-validate the new scale by specialists; 5-application In this research a conceptual list was developed by some researchers, the participants assessed the mentioned list based on a Likert Scale. The Crosby Quality Management Maturity Grid was also used in this study.	According to the questionnaires in which the importance of ergonomics was followed, in some cases especially for contractors, the ergonomics might be ignored.	In this paper the authors emphasize on applications of ergonomics theory and issues in the companies. - The lack of Ergonomics structures produces a break in the program sequences of systems and makes a negative impact on management process, as well. I t means that Ergonomics should be involved with process, project and permanence. -a table guide developed for industrial sectors how to improve the ergonomics conditions.
9	Sonja Pavlovic-Veselinovic-2014	Serbis	Ergonomics as a missing part of sustainability	The relationship between three aspects of sustainability and ergonomics was focused in this paper.	This paper shows that all three aspects of sustainability are related to ergonomics scope. Environmental sustainability is related to physical ergonomics concepts. Also, human reliability and human error which are considered in ergonomics, are related to sustainability concepts.	According to the history of ergonomics and its scope, there is a clear association between ergonomics and sustainability. Also, ergonomics covers several aspects of human life, working environments, human activities, products and users, and so on are included in ergonomics issues.

Table 2. The main articles theme based on the results and conclusion of reviewed articles (Source: Authors)

Authers	Articles' main Theme								
	A	B	C	D	E	F	G	H	I
Pilczuk & Barefield [39]									
Tosi [38]									
García-Acosta et al. [6]									
Andreonia et al. [41]									
Nadadur & Parkinson [40]									
Haslea & Jensen [37]									
Klaus & Fischer [35]									
Cesar Vidala et al. [36]									
Pavlovic-Veselinovic [34]									

DISCUSSION

According to ergonomics scope, to make the human well-being and optimize human- machine performance, all levels of the physical, perceptual, cognitive, emotional, social, organizational, environmental aspects should be considered. In this respect the concept of human machine system has been changed to artifact system-to-human system compatibility. Artifact-human system compatibility has a vast scope and including several sorts of factor and even biological system [29]. There are some other references which emphasized on the broad field of ergonomics scope by introducing by some new terms, i.e. Eco-Ergonomics; green ergonomics [13]; HFE and Sustainability; and Ergoecology [12, 31].

Ergonomics provides the practical methodological approach towards user oriented design not only for products but also for environment. The product designers also play a critical role to create a better life style.

There are two main fields of *ecoefficiency*' and '*ecoproductivity*' in the context of ergoecology. Furthermore, the authors have mentioned that ergoecology consists of three approaches to anthropocentric, sustainability and also systematic [31]. Based on these kinds of reports, it seems that vision of Ergonomics should be expanding to include some aspects of environmental considerations [42].

Beyond the above mentioned themes, decision making for product design is known prominent aspects of development. Ergonomics also has an effective role in the mentioned area. Design for and Sustainability throughout ergonomics consideration is shown the role of ergonomics in the process of productivity and also innovation in product development [36]. Ergonomics may make a comprehensive linkage between human being concepts of design and also other aspects of product design such as sustainability, because of a sustainable product should be a user friendly design [33].

The main concept of sustainability is related to evaluate the quality of human life considering with the carrying capacity of eco-systems. Likewise, the aspects of product design in terms of material recycling and making an appropriated balance between economics aspects of production with other aspects of sustainability are considered by related issues [42].

Based on MDGs and 2030 agenda about sustainability all civil societies, governments, and private sectors should be involved to achieve the sustainability. Furthermore, the sustainability is known as one of the prominent field in all of the societies [43-44]. However, sustainable development alone won't be ended to sustainability targets. Indeed, it may in fact support the longevity of the unsustainable path. In this regards to complete the related actions and improve the quality of life, making integration between ergonomics and sustainability might be ended to better results for the human being and our ecosystem [19].

CONCLUSION

The future is not predictable, but achieving a better life for people is known as a main driving force and encourages us to focus on sustainability and ecological improvement. Undoubtedly this long terms action needs some effective tools and procedures, in this regards the side of green ergonomics plays a critical role.

According to above mentioned and assessed papers, and considering to the Table 1-2 which summarize the scope of ergonomics, product design and sustainability, it seems if we make a synergy between ergonomics and sustainability and introducing a new term which includes all positive aspects of ergonomics whether workstation design or ergonomic product design and also sustainability scope, better framework to implement ergonomics related sustainability will make. In this regards our work introduce an idea about the necessity of development a new multidisciplinary approach. In fact the reviewed papers emphasized on the significance of ergonomics and sustainability; however they didn't mentioned how these two terms integrate together. Our following recommended framework about making a new theme based on integration between ergonomics and sustainability seems new, but this is only a qualitative approach and need more future study to change it to quantitative one, as well.

RECOMMENDATION

To make a practical and planned road map for having an integrated approach based on ergonomics benefits and sustainability scope, we recommend a new multidisciplinary approach entitled "ErgoSustaiNomics". which has more integrated approach than ergoecology and green ergonomics.

ErgoSustaiNomics is known as a term in which all aspects of ergonomics, sustainability and also ergonomic design are considered. This new term helps us to manage the better future life for all. Besides, if the product designers follow the related consideration, their design will be ended to user and environmental friendly products, in terms of product development. It also helps to managers for introducing human center plans in both of industrial based performances or service design.

Figure 4 illustrates the scope of ErgoSustaiNomics as a new multidisciplinary approach .The authors believe that this presented field of science help all of the authorities and experts, managers, and designers to prepare and develop their plans and programs to achieve the better future for all of the societies in terms of quality of life.

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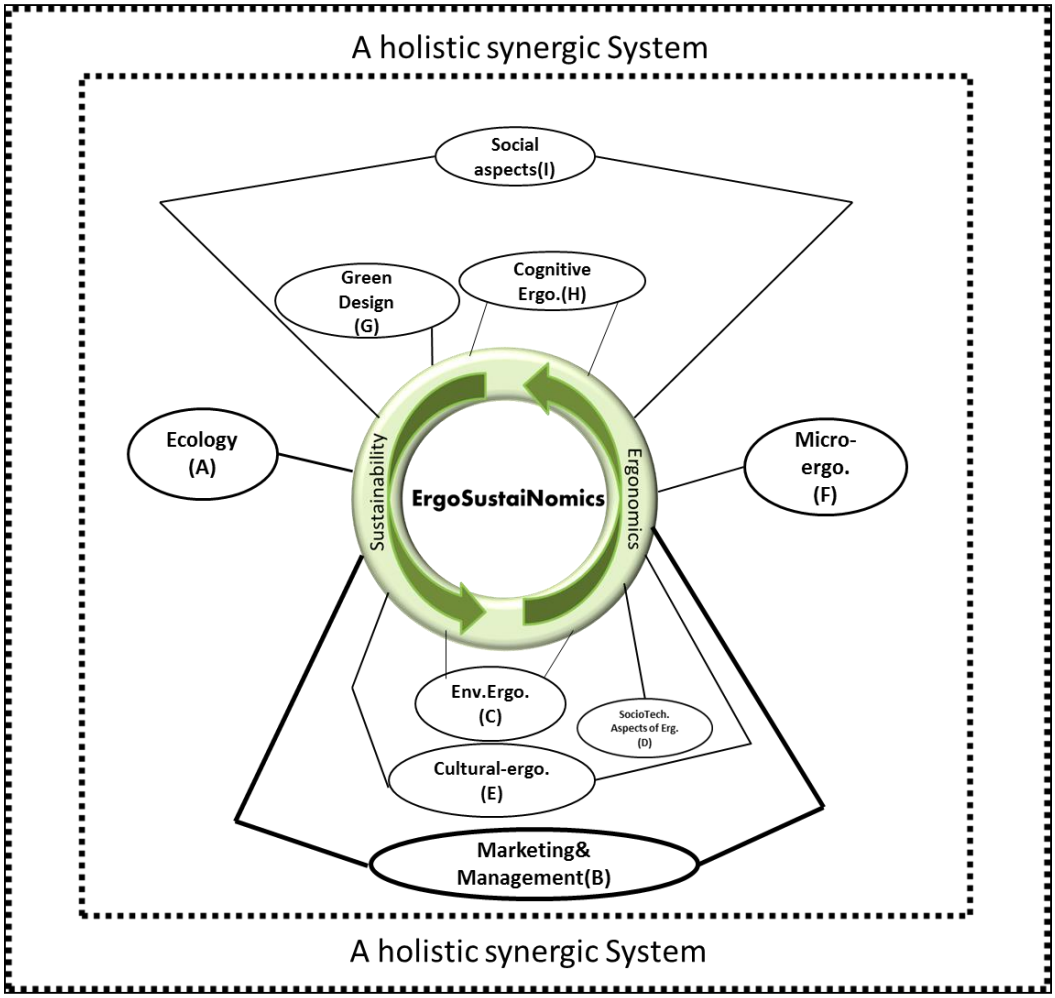

Fig 4. The scope of ErgoSustaiNomics (Source: Authors)

(A): [12,34,38,41], (B):[36-38, 41](C):[12,41];(D):[12]; (E):[38]; (F): [38, 40]; (G):[34, 38]; (H):[34, 41],; (I): [12, 34, 41]

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