

Musculoskeletal Ergonomic Implications in Smartphone Users: A Systematic Review

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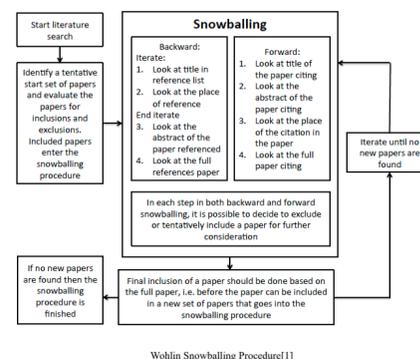
Abstract

This article aims to investigate ergonomic implications with musculoskeletal consequences caused in smartphone users, as well as the identification of methods, techniques and tools that are being used in current studies for the physical evaluation of users of these interfaces. Thus, a systematic review of the literature was performed through the Scopus database, using the Snowballing approach [1] to form the most robust set of documents on the subject addressed. During the document collection processes, 341 articles were found, followed by readings of titles, abstracts and verification of previously established inclusion and exclusion criteria, leaving 27 articles, which were completely analyzed in search of relevant information to fulfill the research objective.

Systematic Literature Review

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- Database: Scopus®;
- Keywords: smartphone + ergonomics + musculoskeletal;
- Publication Period = from 2015;
- Document Type = All;
- Language = English

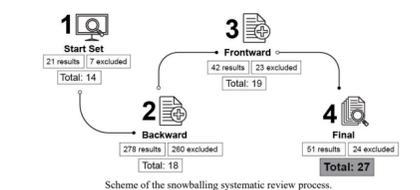


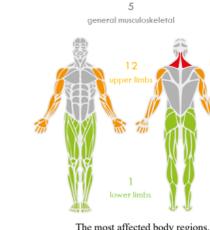
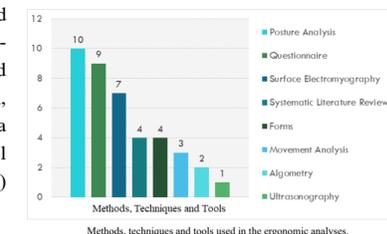
Table 3. Final papers analyzed.

Author, Year	FWCI	Author, Year	FWCI
1. Xie et al., 2016 [7]	7.0	15. Toh et al., 2017 [4]	2.33
2. Lee et al., 2015a [8]	5.34	16. Xie et al., 2017 [5]	2.3
3. Kim e Koo, 2016 [9]	4.31	17. Stalin et al., 2016 [10]	2.11
4. Gustafsson et al., 2017 [11]	4.12	18. Gustafsson et al., 2018 [12]	1.11
5. Yang et al., 2017 [13]	3.65	19. Lee et al., 2018 [14]	1.11
6. Kim, 2015 [15]	3.62	20. Akurke et al., 2018 [16]	1.09
7. Inal et al., 2015 [17]	3.39	21. Tegtmeier, 2018 [3]	1.01
8. Kietrys et al., 2015 [18]	3.1	22. Liang et al., 2016 [19]	0.87
9. Xiong et al., 2016 [20]	2.8	23. Lee e Shin, 2015 [21]	0.77
10. Namwongsa et al., 2018a [22]	2.71	24. Eritvipart et al., 2018 [2]	0.48
11. Kim e Kim, 2015 [23]	2.67	25. Asakawa et al., 2017 [24]	0.47
12. Xie et al., 2018 [25]	2.60	26. So et al., 2017 [26]	0.36
13. Ning et al., 2015 [27]	2.39	27. Namwongsa et al., 2018b [28]	0.33
14. Lee et al., 2015b [29]	2.36	Total Documents = 27	

Data Extraction

In the 27 articles, the body parts that were explored or observed in the studies were verified. The neck or cervical region being related to flexion or angle of inclination of the head, the most mentioned body region (n=13). Then, upper limbs, highlighting: shoulder, arm, forearm, hands, fingers and thumb (n=12). Some studies presented a general approach to musculoskeletal problems (n=5), checking all areas affected by smartphones interaction, including a study (n=1) that indicates inadequate posture of lower limbs.

Regarding the methods, techniques and tools used in the ergonomic analyses, the following were identified and accounted for: Posture Analysis (n=10), Questionnaire (n=9), Surface Electromyography (n=7), Movement Analysis (n=4), Form (n=4), Algomerty (n=2), and Ultrasonography (n=1). The Systematic Literature Reviews (n=4) used a bibliographic research approach, but presented a rich contribution on the biomechanical risks of smartphone use, which can contribute to musculoskeletal alterations as well as the need for more studies to evidence this association.



Results Discussion

After the study was completed, the most affected body regions were identified and studied in the interaction with smartphones, which are: neck and upper limbs (in different regions), and that these were studied to verify variables such as posture, strength, repeatability and duration. Thus, these variables were evaluated through the use of methods, techniques and tools such as: structured questionnaire, posture analysis, surface electromyography (sEMG), form, movement analysis, algometry and ultrasonography, which were combined to check more than one variable in each study.

However, some of the techniques used require specialized knowledge and expensive equipment, such as sEMG and Ultrasonography, making it difficult to include them in the process of interface development. Research is needed to identify more viable ways of evaluating biomechanical issues in digital interfaces, making this type of evaluation feasible for the reality of digital application development offices or even the insertion of professionals specialized in ergonomics to participate in the development and evaluation of these interfaces before they are launched on the market.

Future Works Indications

After identifying the future work indications of each publication, we found some similarities in the authors' proposals and summarized in the following points:

1. To use a consistent and representative sample of users, and to use comparison groups;
2. To conduct longitudinal studies with high scientific quality;
3. To develop ergonomic guidelines for the use of smartphone interfaces;
4. To evaluate realistic situations of use to obtain accurate data, considering the different postures and habits of users;
5. To verify the use of smartphones in work and productivity situations;
6. To consider the different gestures made in the smartphones;
7. To measure the level of discomfort of interaction;
8. To discover new risk potentials, going beyond those already discovered;
9. To carry out a study on the tasks performed in media or social networks, considering the large amount of daily hours dedicated to their use.

Conclusion

In the end, it was possible to realize the importance of conducting more studies on the subject that involves the ergonomics of the gestural interface of smartphones devices, such as the indications of future works presented in the revised articles, as well as taking advantage of the methods, techniques and tools that can be used in further research. However, in view of the market reality of digital interface development offices, these forms of evaluation need to be made possible for their use in the evaluation of interfaces, as well as the need to hire ergonomists to contribute to the development team.

We realized that although there are several studies and evidences that prove the skeletal muscle problems in smartphone users, it is necessary to go further, verifying what can be added to improve this interaction, such as the development of ergonomic guidelines for this type of interface, considering that it is an artifact present in the daily life of a large part of the world population, tending to increase more and more.

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