

# **Improving Mobile Fitness and Weight Loss Apps to Help Saudis Overcoming Obesity**

## **Case Study: Akser Waznk app**

A Thesis Submitted for the Degree of  
Doctor of Philosophy

By

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# CERTIFICATE OF ORIGINAL AUTHORSHIP

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This thesis is wholly my own work unless otherwise reference or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

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# LIST OF PUBLICATIONS

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1. Alturki, R. & Gay, V. 2016, 'A SYSTEMATIC REVIEW ON WHAT FEATURES SHOULD BE SUPPORTED BY FITNESS APPS AND WEARABLES TO HELP USERS OVERCOME OBESITY', *International Journal of Research in Engineering and Technology*, vol. 05, no. 09, pp. 197-206.
2. Alturki, R. & Gay, V. 2017a, 'USABILITY TESTING OF FITNESS MOBILE APPLICATION: CASE STUDY ADED SURAT APP', *International Journal of Computer Science & Information Technology (IJCSIT)*, vol. 9, no. 5, pp. 107-27.
3. Alturki, R. & Gay, V. 2019b, 'The Development of an Arabic Weight-Loss App Akser Waznk: Qualitative Results', *JMIR formative research*, vol. 3, no. 1, p. e11785.

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4. Alturki, R. & Gay, V. 2019a, 'Augmented and Virtual Reality in Mobile Fitness Applications: A Survey', *Applications of Intelligent Technologies in Healthcare*, Springer, pp. 67-75.
5. Alturki, R. & Gay, V. 2019c, 'Usability Attributes for Mobile Applications: A Systematic Review', *Recent Trends and Advances in Wireless and IoT-enabled Networks*, Springer, pp. 53-62.

## CONFERENCE PAPERS PUBLISHED

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# GLOSSARY

3D	Three Dimensional
AI	Artificial Intelligence
ANP	Analytic Network Process
Apps	Applications
AR	Augmented Reality
ASD	Autism Spectrum Disorder
ASQ	After Scenario Questionnaire
AWC/DL	Air War College Distance Learning
BMI	Body Mass Index
CADISS	Coronary Artery Disease in Saudis
CHI	Computer-Human Interaction
CIT	Critical Incident Technique
CUE	Comparative Usability Evaluation
FA	Framework Analysis
GOMS	Goals, Operators, Methods and Selection Rules
HCI	Human Computer Interaction
HTI	Human Technology Interaction
HMD	Head-Mounted Display
HTML	Hypertext Markup Language
IBM	International Business Machines
IEC	International Electrotechnical Commission
IS	Information System

ISO	International Standards Organization
IT	Information Technology
KLM	Keystroke Level Modelling
KSA	Kingdom of Saudi Arabia
LED	Light Emitting Diodes
MIT	Massachusetts Institute of Technology
MUSiC	Metrics for Usability Standards in Computing
NASA	National Aeronautics and Space Administration
NET	Network Satisfaction Scale
PACMAD	People At the Centre of Mobile Application Development
PARC	Palo Alto Research Center
PC	Personal Computer
PEOU	Perceived Ease-Of-Use
PSSUQ	Post Study System Usability Questionnaire
PU	Perceived Usefulness
QUIM	Quality in Use Integrated Measurement
QUIS	Questionnaire for User Interaction Satisfaction
R&D	Research and Development
RMIT	Royal Melbourne Institute of Technology
SA	San Francisco
SEQ	Single Ease Question
SMEQ	Subjective Mental Effort Questionnaire
SMS	Short Message Service
SRI	Stanford Research Institute

SUMI	Software Usability Measurement Inventory
SUS	System Usability Scale
TAM	Technology Acceptance Model
TLX	Task Load Index
TOPSIS	Technique for Order of Preference by Similarity to Ideal Solution
TV	Television
UGC	User-Generated Content
UI	User Interface
UME	Usability Magnitude Estimation
UPA	Usability Professionals' Association
UPT	Usability Problem Taxonomy
US	United States
UXD	User Experience Design
UxPA	User Experience Professionals Association
VR	Virtual Reality
WAP	Wireless Application Protocol
WHO	World Health Organization
WIMP	Windows, Icons, Menus, and Pointer



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# ABSTRACT

Obesity and its related illnesses are a major health problem around the world. Saudi Arabia has one of the highest national obesity rates globally; however, it is not easy to intervene to prevent obesity and overweightness due to Saudi Arabia's cultural and social norms and linguistic barriers. In recent years, there has been an exponential growth in the usage of smartphones and apps in Saudi Arabia. These could be used as a cost-effective tool to facilitate the delivery of behaviour modification interventions for obese and overweight people. There are a variety of health and fitness apps that claim to offer lifestyle-modification tools. However, these do not identify the motivational features required to overcome obesity, consider the evidence-based practices for weight management, consider the social and cultural norms of Saudi society, or enhance the usability of apps by considering usability attributes. Therefore, this research aims at improving mobile fitness and weight loss apps usability guidelines and features to motivate obese users and especially Saudis to lose weight and then overcome obesity. Qualitative and quantitative studies were conducted with 26 obese Saudis who tested the level of usability of two Arabic fitness and weight-loss apps and then provided feedback and recommendations. The following usability attributes were tested: effectiveness, efficiency, satisfaction, memorability, errors, learnability and cognitive load. Qualitative studies were also conducted with seven health professionals (dietitians and physical activity professionals) to evaluate the tested apps regarding their nutrition and physical activity options. This was undertaken in collaboration with the Armed Forces hospitals Taif Region and King AbdulAziz Medical City Ministry of National Guard Health Affairs in Jeddah, Saudi Arabia. Based on the results, comprehensive usability guidelines for fitness and weight loss apps were established and an Arabic weight-loss app called Akser Waznk was developed to facilitate the adjustment of key nutritional and physical activities and behaviours of Saudi users. Akser Waznk app is an interactive, user-friendly app designed primarily for iPhones. It has several features intended to help users to monitor and track their food consumption and physical activities. The app provides personalised diet and weight loss advice. To validate the proposed app, its level of usability was tested and its nutrition and physical activity options evaluated by conducting qualitative and quantitative studies with the same 26 obese Saudi users and the same seven health professionals.