Analysis of type 2 diabetes mellitus and arterial hypertension content in exercise physiology textbooks

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INTRODUCTION

Noncommunicable diseases (or chronic diseases) are characterized as being long lasting with generally slow progression (41). Some of the most prevalent noncommunicable diseases are cardiovascular diseases (arterial hypertension, for example) and diabetes mellitus (14, 44). Sedentary behavior plays an important role in the pathology of these diseases (24), and in the life expectancy (8) and quality of life of persons with the disease.

In regards to arterial hypertension, sedentary behavior is one of the major risk factors for overall mortality and morbidity. It is the most common risk factor for cardiovascular disease (31), which may be aggravated by the presence of other risk factors, such as dyslipidemia, high blood glucose levels, and type 2 diabetes mellitus (T2DM) (18, 19). Concomitant to the increased prevalence of arterial hypertension in the last 3 decades, the prevalence of T2DM has also increased dramatically, both in developed and developing countries. One reason for this is the increase in the sedentary lifestyle (24). According to the World Health Organization, 422 million adults suffer from diabetes mellitus, quadrupling the number since 1980. In fact, 1.5 million deaths were directly attributed to diabetes mellitus in 2012. In Brazil, the mortality rate for diabetes mellitus in 2012 was 38.9/100,000 for females and 39.0/100,000 for males (42), and the prevalence of T2DM and arterial hypertension is rising in parallel with the prevalence of excess weight (36). In addition, 33% of adults over the age of 18 yr are overweight and 10% are obese, both being factors related to the risk of occurrence of diabetes mellitus, which is further increased by their behavioral lifestyle (42).

Arterial hypertension and diabetes mellitus are associated with costly expenditures and the overburdening of public health services; thus the promotion of physical exercise is an effective alternative to attenuate spending on health care and the impact on public health (9, 12). In this context, reputable organizations, such as American College of Sports Medicine (ACSM), advocate the benefits of physical exercise both for individuals with T2DM (10) and arterial hypertension (30). Indeed, regular physical exercise is a key element in the prevention and management of these diseases, since it is well established that participation in regular physical exercise improves control of blood glucose and arterial pressure in T2DM and arterial hypertension, respectively, with positive effects on cardiovascular events, mortality, and quality of life (for review see Ref. 10).
As physical exercise is an important tool for prevention of diabetes mellitus (4, 11, 29) and arterial hypertension (18, 29, 31, 39), accurate knowledge of the different types, volume, intensity, and physiological effects of exercise is fundamental to ensure the effectiveness of exercise programs (28). In addition, the presence of well-trained health professionals to guide and educate the population about the benefits of physical exercise for health is important, since preparing society through health education and promotion is an important strategy to minimize or prevent population health problems (5, 20).

To this end, it is desirable that health-related undergraduate courses provide the student with a solid theoretical, practical foundation of exercise physiology, and textbook content is an important tool for this scenario (25).

Textbooks constitute an important pedagogical tool capable of assisting in teaching practice. Furthermore, textbooks allow students’ interaction with up-to-date scientific information regarding certain subjects and are a crucial part of instructional strategies that aim to promote learning processes among students (13, 40). Therefore, evaluation of exercise physiology textbooks, which students normally see as error free and a source of reliable information, is crucial. To the best of our knowledge, the contents of exercise physiology textbooks have not been evaluated. Furthermore, only one study was identified in which any textbook devoted to higher education was assessed (3). Therefore, the objective of the present study was to analyze T2DM and arterial hypertension contents in exercise physiology textbooks available in Brazil and compare these contents with the scientific information present in the ACSM position stands.

METHODS

Book Selection

All exercise physiology textbooks commercially available in the Brazilian book publishing market were analyzed. Searches were made via the Internet for books with a title containing the expression “exercise physiology.” For the analysis of the exercise physiology textbooks, we opted for the most recent edition available.

Content Analysis

The latest edition of Brazilian exercise physiology textbooks with contents related to T2DM and arterial hypertension were chosen because these are very prevalent clinical conditions in the population (14, 44).

Selection of reference articles. The official ACSM position stands on arterial hypertension (30) and T2DM (10) were used as references. ACSM position stands were adopted because ACSM is the main organization of sports medicine and exercise science (1, 6), and also because ACSM position stands contain information about the level of scientific evidence for arterial hypertension and T2DM. The levels of evidence were categorized as A, B, C, or D, in descending order of scientific accuracy. Level A evidence comes from randomized controlled clinical trials with abundant data; level B evidence corresponds to randomized controlled trials, but with limited data; level C evidence relates to nonrandomized trials and observational studies; and level D evidence corresponds to expert opinion.

Analysis tools. A guiding document was created to allow for the organization of the analysis of each exercise physiology textbook into a schematic model. The topics addressed in the guiding document were as follows: 1) presence of content related to the disease contents (T2DM and arterial hypertension); 2) purpose of the exercise; 3) exercise prescription (intensity, volume, and frequency); 4) types of exercise (aerobic and resistance training); 5) general care and recommendations; 6) benefits of the exercise; and 7) physiological mechanisms.

First, the information obtained from the reference articles was transcribed. Second, information present in the exercise physiology textbooks was transcribed as well, with analysis of differences from the contents of the reference information and highlights of incorrect information identified in the textbooks. To this end, the textbooks were carefully analyzed to locate texts, chapters, or quotations that pertained to T2DM and arterial hypertension. After these contents were located, a careful reading of the material was performed, which was transcribed into the guiding document. For each of the analyzed textbooks, a guiding document was filled out. Each textbook was analyzed for the presence of concepts from the reference article, with the concepts categorized as contemplated, partially contemplated, or not contemplated.

Analysis stages. The present study was conducted in two stages, adapted from the methods of Franzolin (15) and Mohr (26). The first stage consisted of evaluating the presence or absence of contents related to arterial hypertension and T2DM in the exercise physiology textbooks. The second stage consisted of evaluating the quality of the content and how close or distant it was from the ACSM position stands. Therefore, the information present in the textbooks was classified as follows: 1) contemplated, where the contents of the reference were explicitly and completely discussed in the textbooks; 2) partially contemplated, where the contents of the reference were partially discussed in the textbooks or were approached implicitly; and 3) not contemplated, where the contents of the reference were not present in any transcription or passage of the textbooks. This method allowed for tabulation of the frequency with which the contents were contemplated or not, and also if topics important for the prescription of exercise were present in some of the transcriptions of the textbooks of exercise physiology.

RESULTS

Textbooks Included in Analysis

Ten textbooks were found in the Brazilian book publishing market and composed the material to be analyzed (Table 1). All textbooks analyzed had content or words related to T2DM and arterial hypertension. It is noteworthy that we analyzed versions of textbooks translated into Brazilian Portuguese, except for the Pithon-Curi (32), Raso et al. (35), and Andrade and de Lira (2) textbooks.

Analysis of Contents Related to Arterial Hypertension and Type 2 Diabetes Mellitus

Type 2 diabetes mellitus. Eight of the ten exercise physiology textbooks (80%) analyzed contemplated information regarding the purpose and benefits of physical exercise for individuals with T2DM (2, 7, 21–23, 33–35), in a manner consistent with the reference information (10). One textbook (10%) partially contemplated (24) and one textbook (10%) did not contemplate information regarding the purpose and benefits of exercise for individuals with T2DM (32).

In regards to exercise prescription, which includes factors such as intensity, frequency, and duration of exercise, only 20% (n = 2) of the textbooks analyzed contemplated this information clearly and within the approximation of the ACSM position stands (22, 35), whereas 20% (n = 2) of the textbooks only partially contemplated this information (23, 34), mainly because they addressed exercise prescription for only one type of exercise (generally) aerobic. Six textbooks (60%) provided...
only extremely scarce information about the volume and intensity of exercise for individuals with T2DM (2, 7, 21, 24, 32, 33), without contemplating information from the ACSM position stands.

Regarding the type of exercise, 70% (n = 7) of the textbooks analyzed contemplated this topic with a direct approach to the reference information (2, 7, 21, 22, 32, 34, 35), indicating the specific combination of aerobic and resistance exercise. In contrast, 30% (n = 3) of the textbooks (23, 24, 33) did not provide any such information.

All textbooks (2, 7, 21–24, 32–35) contemplated the topic of general care and recommendations for people with T2DM. Six textbooks (60%) were considered more fully within approximation to the reference content (2, 7, 22–24, 35), whereas the remaining textbooks (n = 4; 40%) contemplated this content partially (21, 32–34), citing only some information from the ACSM position stands.

Regarding the physiological mechanisms responsible for improvement in the management of T2DM (i.e., muscular contractions stimulate the increase of glucose transport, mediated by the glucose transporter-4 of skeletal striated muscle), one-half of the textbooks (n = 5) contemplated this topic (2, 7, 21, 22, 35), presenting the mechanism involved. One textbook (10%) contemplated this partially (34), limited to a mention that physical exercise increases the uptake of glucose. In 40% (n = 4) of the textbooks analyzed, we did not identify information related to the topic “mechanisms” (23, 24, 32, 33).

Quantitative results related to the concept of regular physical exercise for individuals with T2DM in the analyzed textbooks are presented as absolute and relative frequencies in Table 2. Arterial hypertension. All textbooks analyzed (2, 7, 21–24, 32–35) contemplated the topic related to the exercise and its benefits in terms of arterial hypertension. Forty percent of the analyzed textbooks (n = 4; 40%) did not contemplate the topic of exercise prescription (7, 21, 23, 33), contemplating only the intensity. On the other hand, 60% (n = 6) of textbooks analyzed contemplated all aspects recommended by the ACSM position stands in regards to exercise prescription (frequency, volume, and intensity) for individuals with arterial hypertension (2, 22, 24, 32, 34, 35), of which four studies (2, 22, 32, 35).

Table 1. Exercise physiology textbooks included for analysis

| Authors                          | Year | Title                                                                 | Edition | Publisher             |
|----------------------------------|------|----------------------------------------------------------------------|---------|-----------------------|
| McArdle et al. (23)              | 2002 | Fundamentos de Fisiologia do Exercício [Essentials of Exercise Physiology] | 2nd     | Guanabara Koogan      |
| Plowman and Smith (33)           | 2010 | Fisiologia do Exercício—Para Saúde, Aptidão e Desempenho [Exercise Physiology for Health Fitness and Performance] | 2nd     | Guanabara Koogan      |
| Brooks et al. (7)                | 2013 | Fisiologia do Exercício: Bioenergetica Humana e Susas Aplicações [Exercise Physiology: Human Bioenergetics and Its Applications] | 4th     | Phorte                |
| Kenney et al. (21)               | 2013 | Fisiologia do Esporte e do Exercício [Physiology of Sport and Exercise] | 5th     | Manole                |
| McArdle et al. (24)              | 2013 | Fisiologia do Exercício: Nacção, Energia e Desempenho Humano [Exercise Physiology: Nutrition, Energy, and Human Performance] | 7th     | Guanabara Koogan      |
| Pithon-Curi* (32)                | 2013 | Fisiologia do Exercício [Exercise Physiology]                          | 1st     | Guanabara Koogan      |
| Raso et al.* (35)                | 2013 | Pollock: Fisiologia Clinica do Exercício [Pollock: Clinical Exercise Physiology] | 1st     | Manole                |
| Powers and Howley (34)           | 2014 | Fisiologia do Exercício—Teoria e Aplicação ao Condicionamento e ao Desempenho [Exercise Physiology—Theory and Application to Fitness and Performance] | 8th     | Manole                |
| Kraemer et al. (22)              | 2016 | Fisiologia do Exercício—Teoria e Prática [Exercise Physiology—Theory and Practice] | 2nd     | Guanabara Koogan      |
| Andrade and de Lira* (2)         | 2016 | Fisiologia do Exercício [Exercise Physiology]                          | 1st     | Manole                |

*Textbooks available only in the Portuguese language.

Table 2. Quantitative analysis of the contents of exercise physiology textbooks related to T2DM and hypertension

| Approach to Reference | T2DM | Arterial hypertension |
|-----------------------|------|-----------------------|
|                       | n    | %                     | n    | % | n    | % |
| Purpose and benefits of exercise | 8/10 | 80 | 1/10 | 10 | 1/10 | 10 |
| Exercise prescription | 2/10 | 20 | 2/10 | 20 | 6/10 | 60 |
| Type of exercise | 7/10 | 70 | 0/10 | 0 | 3/10 | 30 |
| General care and recommendations. | 6/10 | 60 | 4/10 | 40 | 0/10 | 0 |
| Mechanisms involved | 5/10 | 50 | 1/10 | 10 | 4/10 | 40 |
| Purpose and benefits of exercise | 10/10 | 100 | 0/10 | 0 | 0/10 | 0 |
| Exercise prescription | 6/10 | 60 | 0/10 | 0 | 4/10 | 40 |
| Type of exercise | 9/10 | 90 | 0/10 | 0 | 1/10 | 10 |
| General care and recommendations. | 2/10 | 20 | 4/10 | 40 | 4/10 | 40 |
| Mechanisms involved | 7/10 | 70 | 0/10 | 0 | 3/10 | 30 |

Values are no. (n) and percentage of textbooks in which the topic was contemplated (C), partially contemplated (PC), or not contemplated (NC). T2DM, type 2 diabetes mellitus.
separately reported prescription information for resistance and aerobic exercise. In addition, 90% \( (n = 9) \) of the textbooks analyzed contemplated and defended the application of aerobic exercise supplemented with resistance exercise \( (2, 7, 21–24, 32, 33, 35) \), whereas in the remaining textbook \( (34) \) this information is absent.

Most textbooks \( (60\%; n = 6) \) contemplated the topic of general care and recommendations for individuals with arterial hypertension \( (2, 7, 32–35) \); two textbooks fully contemplated \( (32, 35) \) this topic. Four textbooks only partially contemplated this topic \( (2, 7, 33, 34) \), since some significant aspects punctuated by the ACSM position stands were neglected, such as the importance of physical evaluation, individual and constant monitoring, a physical exercise test limited by symptoms, and considerations about medication use and its side effects. In addition, 40% \( (n = 4) \) of the textbooks analyzed \( (21–24) \) did not present any content related to general physical exercise care and recommendations for individuals with arterial hypertension.

Seven textbooks \( (70\%) \) contemplated the topic related to the possible mechanisms involved in the interaction between physical exercise and reduction of arterial hypertension, highlighting the neurohormonal, vascular, and structural changes involved \( (2, 7, 21, 23, 24, 32, 33) \). In the remaining three textbooks \( (22, 34, 35) \), no topics were identified that contemplated the possible mechanisms involved in the hypotensive effect of the exercise.

Quantitative results related to the concept of regular physical exercise for individuals with arterial hypertension in the analyzed textbooks are presented as absolute and relative frequencies in Table 2.

**DISCUSSION**

The aim of the present study was to analyze exercise physiology textbooks available in the Brazilian book publishing market for content about T2DM and arterial hypertension and to compare these contents with scientific information present in the official ACSM position stands for individuals with T2DM or arterial hypertension. We found that all exercise physiology textbooks that were analyzed presented information about the relationship between physical exercise and T2DM and arterial hypertension. However, only six of all analyzed textbooks considered characteristics related to the exercise prescription, from the goals and benefits of the exercise (the most contemplated aspect) to the physiological mechanisms involved in mediating the benefits of physical exercise for the evaluated diseases.

Regarding T2DM, the topics contemplated, in descending order, were the general care and recommendations for regular physical exercise, purposes and benefits of exercise, type of exercise, physiological mechanisms, and exercise prescription, which was completely contemplated only in two of the analyzed textbooks \( (22, 35) \). Since the desired effect is dependent on the prescribed dose of exercise \( (34) \), it is important that there be the presence of accurate information in exercise physiology textbooks. Therefore, this result highlights a negative aspect from the analysis of exercise physiology textbooks, since in most of them there is no information that allows full inferences to be made for the application of physical exercise in individuals with T2DM.

The lack of availability of parameters related to training, such as intensity, frequency, and duration, which are presented as a B-level of evidence by the ACSM, in the analyzed exercise physiology textbooks may negatively affect the prescription of physical exercise in clinical practice. Indeed, the lack of a clear definition of exercise prescription for each type of exercise (aerobic and resistance exercise) for individuals with T2DM is worrisome, because, in clinical practice, it is necessary to precisely define these parameters and establish the correct and optimum dose of exercise that provides the greatest benefits to patients with T2DM. Therefore, health professionals that use these exercise physiology textbooks can present an impairment in professional performance and, consequently, cause prejudice to clinical status of patient.

In this context, it is important that current evidence-based information is included in exercise physiology texts, since Morton et al. \( (27) \) reported that 8 of 10 misconceptions about exercise physiology and biochemistry prevailed throughout the course of the degree program, suggesting that students enter and leave university with the same misconceptions in certain areas of exercise physiology and biochemistry. Specifically, Morton et al. \( (27) \) found misconceptions concerning blood pressure responses during exercise in hot ambient conditions that induce dehydration, demonstrating that students do not appear to understand how blood pressure is regulated in response to physical exercise. Thus an adequate education and training of health professionals is fundamental.

In addition, individual resistance training supervision by a specialized professional may help to control important training variables such as load, rest intervals, and exercise techniques, and help to provide motivation and psychological reinforcement \( (16) \). Gentil and Bottaro \( (17) \) found that strength gains for both lower- and upper-body muscles are greater in subjects training under higher supervision ratios (high, 1:5 coach-to-athlete ratio) compared with low supervision ratios (low, 1:25).

Cradock et al. \( (11) \) showed that interventions in which the physical exercise component was supervised (e.g., contact with an exercise physiologist) had more evident effects on the reduction of glycosylated hemoglobin in patients with T2DM, in terms of both aerobic and strength exercise. This reinforces the importance of the prescription of exercise by trained and well-oriented professionals.

Information regarding exercise for arterial hypertension, the most common, costly, and avoidable risk factor for cardiovascular disease and one of the most important public health problems \( (19, 31) \), was included in all physiology textbooks analyzed. The topics best contemplated, in a descending order, were the objectives and benefits of the exercise, type of physical exercise, physiological mechanisms involved, exercise prescription, and general care and recommendations for the regular practice of physical exercise. We highlight the latter two aspects, since it is important to take care with these individuals (e.g., previous medical evaluation and constant monitoring), especially in the advanced stages of hypertension, since these individuals may present associated comorbidities, such as concomitant arterial hypertension and T2DM, which has significant repercussions on health and the care that is needed \( (18) \).

The presence of correct information in textbooks used by students and health professionals, especially those in primary care, such as textbooks related to adequate prescription of
physical exercise, can help in the effective combat of arterial hypertension and influence the achievement of the sixth overall objective of the World Health Organization, which aims to reduce arterial hypertension prevalence by 25% by the year 2025 (43). Exercise prescription includes essential factors that are needed to obtain a good level of physical conditioning and health, and, moreover, physical exercise prescription is an important therapeutic strategy at all levels of prevention for this chronic disease (34, 38).

In this context, although 90% of the exercise physiology textbooks analyzed were published between 6 and 12 yr after the year of publication of the ACSM position stands on exercise and arterial hypertension, a considerable portion of these textbooks do not contain any information about the prescription of physical exercise, an important therapeutic strategy. Pescatello et al. (31) performed a study to obtain an overview of the recommendations regarding the principles of exercise prescription and to present an updated exercise prescription for adults with arterial hypertension, integrating existing recommendations with new and emerging research. Briefly, the indication corresponds to a combination of ≥30 min/day of moderate-intensity aerobic exercise, preferably every day of the week, and strength exercises 2–3 days/wk, for a total of ≥150 min of exercise/wk. Therefore, in light of current scientific knowledge, exercise for people with hypertension should involve the combination of aerobic and strength exercises.

Important translation errors in the seven exercise physiology textbooks translated into Portuguese were also found, such as a misleading translation of the term “resistance training” in four (57.1%) of the seven translated textbooks. The term “resistance training” refers to “strength training.” However, this term has been translated as “endurance training,” which is synonymous with “aerobic exercise.” Therefore, this translation error can generate misconceptions in students and health professionals.

Finally, despite technological innovations and greater availability of information, especially for individuals enrolled in higher education, studies reinforce the concept that the printed textbook continues to be primarily used by undergraduates in the search for information and is preferred in comparison to electronic textbooks (13, 40). Shepperd et al. (37) evaluated the purchasing pattern of undergraduate students and found that 90% of students who had the option to buy either an e-book or a more expensive printed textbook opted for the printed text. Thus these findings show the importance of printed textbooks.

**Study Limitations**

Despite the important results found in this study, some limitations need to be highlighted. First, there is a lack of studies involving the analysis of textbooks in higher education, making it difficult to compare our findings with results of previous work. Second, subjective analysis can increase the risk of bias. Third, analysis of the Portuguese versions of exercise physiology textbooks can be influenced by errors in translation. For this reason, it is recommended to read original versions of textbooks in English. Nevertheless, we believe that these limitations do not prevent the conclusions of this study to be drawn.

**Conclusions**

All textbooks analyzed in the present study presented contents related to physical exercise for patients with T2DM and hypertension. However, the textbooks presented differences in the quality of the contents, especially in relation to exercise prescription. In addition, despite all exercise physiology textbooks contemplating, in different ways, exercise for T2DM and arterial hypertension, we emphasize the need for stronger and better considered aspects of this concept for clinical application, since this knowledge, when based on strong exercise physiology evidence, allows present and future students and health professionals who are in contact with the studied population to provide safe and effective interventions. In addition, due to the indisputable benefits of regular physical exercise as a tool used in prevention and treatment programs for T2DM and arterial hypertension, it is important that students and health professionals have the correct knowledge about the applicability of concepts inherent in exercise physiology.

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**DISCLOSURES**

No conflicts of interest, financial or otherwise, are declared by the authors.

**AUTHOR CONTRIBUTIONS**

C.A.B.d.L., N.F.L., R.L.V., and M.S.A. conceived and designed research; C.A.B.d.L., N.F.L., and M.S.A. performed experiments; C.A.B.d.L., N.F.L., and M.S.A. analyzed data; C.A.B.d.L., M.H.C., and M.S.A. interpreted results of experiments; C.A.B.d.L., R.B.V., M.G.d.S., M.H.C., R.L.V., and M.S.A. drafted manuscript; C.A.B.d.L., R.B.V., M.G.d.S., M.H.C., R.L.V., and M.S.A. edited and revised manuscript; C.A.B.d.L., R.B.V., M.G.d.S., M.H.C., R.L.V., and M.S.A. approved final version of manuscript.

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