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Most Undergraduate Exercise Physiology Courses Favor Teleological Reasoning: How Prior Coursework Can Influence Education

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ABSTRACT:
Among many students, physiology is known as a tough field, leading to more students dropping out and failing the course. The subject's structure, methods used for instruction and ways students process and understand physiology are among the reasons it is hard to master this field. A question that is still unclear is how students in exercise physiology reason about causes versus outcomes. This work intended to discover: 1) whether students mainly relate cardiorespiratory exercise changes through purpose- or science-based thinking and 2) whether prior study of physiology increases one way of thinking more than the other. Nine incomplete statements about exercise physiology were added to an online questionnaire as part of the analysis. Every participant was given the option to answer using a teleological or mechanistic explanation for each of the examples. Students in the study all belonged to one of three groups: Movement Sciences (152), Health-related fields (81) or Other (64). Students in these first two categories were also differentiated according to whether they had prior experience in a physiology class. Across the different groups, teleological explanation was common in 58% of all responses. Students not majoring in health fields showed much higher rates of teleological thinking ($76 \pm 16\%$) compared to Movement Sciences students ($61 \pm 25\%$) and those in Health ($58 \pm 26\%$) ($P < 0.01$). Students who had learned physiology courses in their background explained phenomena much less often using teleology ($59 \pm 25\%$) than students who had not learned these courses ($72 \pm 22\%$) ($P < 0.01$). Still, most of the students, even those with previous physiology instruction, relied mostly on teleological thinking. Generally, undergraduate students use outcome-based reasoning when considering the body's responses during physical activity. While prior learning in physiology can decrease a tendency to think this way, it is not always completely removed. Results suggest teleological thinking might persist no matter how much formal instruction is given in the subject.

KEY WORDS: Exercise science, Students at the undergraduate level, Reasoning by outcome, Biological instruction, Strategies for teaching physiology.

INTRODUCTION:

Exercise physiology plays a crucial role in deepening our understanding of how physical activity influences bodily systems. Despite its importance, physiology is often seen as a challenging subject, potentially contributing to high rates of course withdrawal and academic failure (1). This difficulty can stem from the inherent complexity of the field itself, as well as from factors related to teaching methods or students' perceptions of the subject. A review of definitions from major physiological organizations highlights that the concept of "function" is central to physiology (2). However, this concept is debated in scientific education due to its connection with teleological thinking—where biological phenomena are explained in terms of purpose or outcomes rather than causes For instance, saying "we breathe because we need oxygen" emphasizes the purpose or consequence of breathing while overlooking the actual physiological mechanisms, such as the role of neural and chemical receptors in respiratory control (3). In the context of science education, providing accurate explanations of biological processes is critical. Yet, it remains unclear how learners in exercise physiology interpret physiological functions—whether their reasoning is rooted more in outcomes (teleological thinking) or in biological causes (mechanistic thinking) Research has shown that individuals, regardless of age, have a natural tendency to explain biology using teleological reasoning. In one study, learners at different academic levels were presented with human physiological phenomena and asked to choose between purpose-drive and cause-driven explanations (4,5). The results indicated a strong preference for teleological reasoning across most participants. Understanding how students interpret physiological responses during exercise is essential to preventing persistent misconceptions. These misunderstandings often arise from confusing the effect of a physiological process with the underlying cause. While both teleological and mechanistic reasoning have educational value, an overreliance on teleological thinking can result in incomplete understanding and hinder scientific reasoning Despite these concerns, little is known about how exercise physiology students apply these forms of reasoning (6). Furthermore, the influence of prior coursework in physiology on students' tendency toward teleological or mechanistic explanations has not yet been clearly established Therefore, this study aimed to assess (1) whether students primarily use teleological or mechanistic thinking when interpreting cardiorespiratory responses during exercise, and (2) whether prior exposure to physiology courses affects this preference. We hypothesized that students predominantly use teleological reasoning, but that this tendency would be less pronounced among those who have previously studied physiology. If supported, the results could highlight how exposure to foundational physiology can help shift students toward more scientifically grounded explanations.

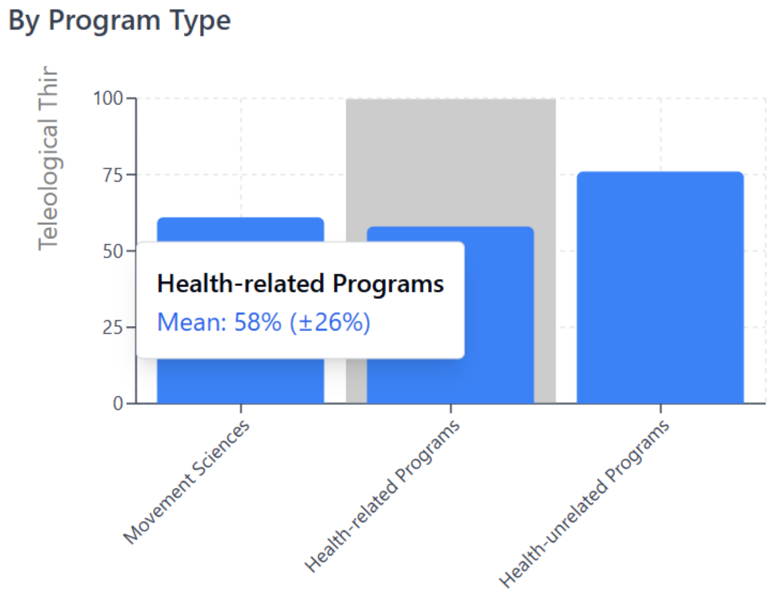
METHODS:

The present study involved undergraduate students from various academic departments within a public institution. All research procedures were conducted following approval from the institution's Research Ethics Committee and adhered to internationally accepted ethical standards for human research. Prior to participation, each student provided written informed consent after being informed that their involvement was voluntary and that they could withdraw from the study at any point without consequence. The consent form was thoroughly reviewed by each participant and subsequently sent to them via email for reference Participants were categorized based on their field of study into three groups: Movement Sciences (n = 152), Health-related programs (n = 81), and programs unrelated to health or human biology (n = 64). Both Movement Sciences and Health-related groups included physiology coursework in their curricula, with Movement Sciences students specifically engaging in exercise physiology classes, while those in Health-related programs studied more general physiology topics. In contrast, students from programs unrelated to health sciences had no exposure to physiology content Within the Movement Sciences and Health-related groups, participants varied in their prior physiology education. Some students had completed one or more physiology courses, whereas others had no previous coursework in this area. Accordingly, analyses for these groups were further divided into students with prior physiology education and those without. Since students from non-health-related programs had no physiology training, this group was treated as a single category without further subdivision To assess students' conceptual reasoning regarding exercise physiology, an online questionnaire consisting of nine incomplete statements was utilized. These items were adapted from previous research but tailored to focus specifically on exercise physiology concepts. Each statement required students to choose between teleological (purpose-driven) or mechanistic (cause-driven) explanations for physiological responses to exercise. The questionnaire was reviewed and refined by two field experts to ensure its ability to effectively differentiate between the types of reasoning. The instrument's discriminative capacity was confirmed in a pilot study involving 32 sport science students. After completing th questionnaire, these students attended a brief instructional session contrasting teleological and mechanistic explanations, then retook the questionnaire. Following this session, teleological responses dropped significantly to 17%, validating the questionnaire's sensitivity in distinguishing students' reasoning styles.

Table 1: Mean Percentage of Teleological Thinking Across Different Student Groups and the Effect of Prior Physiology Course Enrollment

Group / Condition	**Mean Teleological Thinking (%)**	**Standard Deviation (%)**	**Statistical Significance**
By Program Type			
Movement Sciences	61	25	No significant difference vs. Health-related ($P = 0.324$)
Health-related Programs	58	26	Significantly lower than Health-unrelated ($P < 0.000020$)
Health-unrelated Programs	76	16	Significantly higher than Health-related and Movement Sciences ($P < 0.000020$)
By Prior Physiology Enrollment			
With Prior Physiology Courses	59	25	Significantly lower than no prior enrollment and Health-unrelated ($P = 0.000001$)
Without Prior Physiology Courses	72	22	Significantly higher than with prior enrollment ($P = 0.000001$)
Health-unrelated Programs (no physiology courses)	76	16	Same as above

Figure 1: Mean Percentage of Teleological Thinking Across Student Groups



RESULT:

Findings indicate that students' teleological thinking is shaped according to what they have studied and whether they have taken earlier courses in physiology. The majority of students from every group explained physiology in terms of goal-direction rather than in terms of how mechanical events work. Students who did not pick health-related programs scored highest in teleological reasoning, averaging 76% teleological answers. The rate in engineering was much higher than in health-based (58%) or movement science (61%) programs. It appears that the relatedness of movement sciences and health-related subjects may shape their perspectives on explaining exercise physiology by using concepts learned through physiology. There was a further look into how well previous physiology lessons aligned with current learning in movement sciences and health groups. Students who had taken physiology were much less likely to think in terms of teleology (59%) than students without any prior experience in physiology (72%). It suggests that by being taught physiology, students could use mechanical explanations instead of those based on function. While their understanding was better, students with past experience in physiology still mainly used teleological views, proving that this approach often endures in the field. Because the teleological group was not taught topics related to physiology, they kept the most teleological thinking, since they heard less about science approaches. Importantly, analyzing the data showed that those with prior physiology training had different views, pointing to how prior education strongly affects conceptual thinking. The research also showed that giving explanations only in terms of outcomes — instead of the reasons behind them — can easily lead to misunderstandings. The study found that undergraduate students mostly explain how cardiorespiratory physiology works during exercise using teleological reasoning. Although previous lessons in physiology reduce this tendency somewhat, it appears that teleological thinking is only partly affected by teaching. The insights stress that teaching strategies should directly focus on the different concepts of teleological and mechanistic explanations. Using these approaches can help students build a wider and more scientific view of how the body works which improves their understanding of exercise physiology.

DISCUSSION:

It tested if students choose teleological reasoning over mechanistic reasoning while interpreting cardiorespiratory physiology during exercise and how taking physiology courses changes their preferences (7,8). Teleological thinking clearly dominated the responses of each group, as each reported a preference above 58%. Those in school without medical or movement specializations had much stronger teleological reasoning than students in health and movement fields. Individuals with physiology in their academic history had a lower level of teleology, yet this viewpoint still made up about 60% of all answers. Therefore, taking a previous physiology course does not appear to change the styles of thinking much. The kind of physiology course taken—be it exercise or general physiology—did not seem to affect the result. In general, the findings show that students mainly think about exercise physiology in teleological terms and that their earlier physiology instruction does not influence this dominant thinking pattern. Prior studies have shown what students think about human body functions and what that offers for teaching physiology. Based on his pioneering efforts, Richardson saw that high school and undergraduate students often had teleological ideas about physiology. It's worth noting that the percentage of teleological thinkers in this study, with previous classes in physiology, is about the same as Richardson's 59% figure. The proportion is remarkable because statistics is largely based on science. Second, review of biology research suggests that overall, students who did not have previous physiology classes often thought more in a teleological way compared to those who had the coursework. As shown by earlier studies, there is no major difference in teleological thinking between biology students at different levels of schooling (9). Instead, it shows that using interventions focused on distinguishing mechanistic from teleological explanations can work better. Teleological thinking is found in everyday life largely because of how our primitive notion of causality was formed. Vosniadou believes that simple theories children create as children grow but may sometimes guide them astray when they are tested by science. In the same way, DiSessa proposes that there are simple, everyday ideas, known as phenomenological primitives, used in usual explanations but differing from scientific truth. Because of these cognitive frameworks, we can understand why students continue to use teleological reasoning. Kelemen has shown through research that children and adults often use teleological reasoning because of early thoughts about intent and purpose which they later improve and maintain (7). While not part of this study, presenting teleological concepts apart from mechanistic ones could improve and broaden student understanding of physiology. Richardson's work agrees with this idea because he finds that addressing these differences in education can greatly decrease teleology. Most people consider physiology a tough area to study, usually more because of the topic than the way it is taught. Still, students and instructors find that using causal and teleological thinking can make learning ineffective, but these issues could be overcome by organizing causes and effects more clearly. Modell and others point out that correcting student misconceptions and giving them ways to change their ideas is key for understanding science. Students should participate in activities since they need to check and revise any ideas they have that may be wrong. It appears that using case-based learning greatly reduces many common mistakes in physiology and this suggests that handling cases in critical discussion can minimize false teleology errors. Through deep learning, solid teaching plans and proven strategies, a person can develop mechanistic reasoning, however, this takes careful learning and frequent participation. Integrating nature of physiology in instruction may increase how much students learn about it. Mixing hands-on projects with school lessons has led to better levels of student engagement and memory, proven by research. Special laboratory work on how exercise changes the body's heart rate has been proven to greatly improve students' knowledge and respect for physiology. They can prevent students from mistakenly thinking about teleological ideas and may improve their ability to describe physiology by allowing them to see and do the examples. Next, it would be helpful to study the ways in which students' teleological and mechanistic thinking in physiology changes when different teaching approaches are used. Some problems need to be considered before drawing conclusions from this study. There may be students who gave teleological answers because they didn't understand the terminology in the mechanistic answer options. Instead, it may come from a tendency in science instruction to focus on outcomes rather than actual causes (10). The survey questions were shaped after confirmed tools and explored simple changes in body and breathing. Other things such as being able to use the survey at any time, checking outside information, variation in coursework, being close to patient care, student's age and year and modifications in teaching materials could have affected the survey's results. In addition, the test only allowed one choice per question without further questions to clarify which can result in students doing little more than guessing.

CONCLUSION:

Results suggest that most undergraduate students explain aspects of cardiorespiratory physiology during exercise by using teleological reasons, even when they have had different prior education experiences. For students not focusing on health, teleological thinking was highest, but for those who had learned physiology before, only minimal progress was seen toward mechanistic ways of thinking. Teleological thinking seems to be a strong mental pattern that originates from early development and common approaches to biology. These findings show that it is hard for educators to help students understand physiology in a mechanistic way without starting with teleological ideas. Using teleological ideas works well for quick understanding at the beginning, but it can start you on the wrong track if the important causes are overlooked. For this reason, teachers should include activities that compare mechanistic and teleological approaches to physiology, helping students build a full understanding of this field. Case studies and practical examples seem effective in helping students understand how the body works by giving them direct experience with important physical processes. The use of these methods can boost student motivation, increase what is understood and help students understand why something occurs, rather than just its outcomes. Even so, to change students' reasoning, educators must commit, communicate clearly and organize curricula to include both learning concepts and their applications. The outcome of this study should take into account the use of unfamiliar terms, no restrictions on who answered the questionnaire and different ways students are taught. In the future, we should examine if targeted educational activities aimed at shifting from teleology to mechanics in physiology help improve learning. Generally, these findings help educators improve curriculum design so students can overcome common misunderstandings and better understand the human body.

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