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The Benefits and Implementation of Open Science Practices in Exercise Science Research

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THE BENEFITS AND IMPLEMENTATION OF OPEN SCIENCE PRACTICES IN EXERCISE
SCIENCE RESEARCH

By

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Summary

This article has the purpose of addressing the need for open science practices in the field of exercise science research. Open science is best defined as the call for greater accessibility and transparency in research (Chakravorty et al., 2022). With more accessible and transparent research, research can be conducted more thoroughly and efficiently. Additionally, the implementation of these practices would discourage many shady and unethical practices. The idea of open science is not without debate however. There are many concerns over the theft of scientific data and ideas, as well as the increased time and monetary costs associated with many of these practices. This narrative review addresses many of these issues, as well as provides potential solutions to issues currently facing exercise science research. The field of exercise science was chosen due to the lack of literature available on this topic within the field.

1. Introduction

Science is one of the most important tools humans have at their disposal. Without the revelation of many scientific discoveries, much about ourselves and the universe as a whole would be unbeknownst to all. Science builds on itself. A substantial amount of what we know today is the result of the furthering of scientific knowledge that was discovered prior. However, just as there were hundreds of years ago, barriers are present that stunt the furthering of science. Although there is much more scientific information at our disposal now due to the evolution of technology and the internet, our system of accessing, writing, and reporting research is far from perfect.

As it stands now, the majority of research can be categorized as relatively closed. Although non-malicious in intent, it is currently standard practice to both require payment to access many research articles, and to not disclose certain important information to readers and other researchers, such as raw data or in-depth methodology, that could otherwise be utilized for the furthering of scientific understanding.

Open science is the call for greater accessibility and transparency in research (Chakravorty et al., 2022). There are many benefits to open science practices such as ease and quality of replication, free access to publications, and the potential to increase study reliability, however, it is not a topic without debate and potential drawbacks. With good reason, there are concerns about the time commitment, monetary costs, and overall effectiveness of open science practices. Although not all encompassing, this article has the intent to address many open science practices, their benefits, drawbacks, and potential implementation in the field of exercise science. This article will navigate the topics of preregistration, publication access, raw data disclosure, outcome switching, methodology reporting, publication bias, and the file-drawer effect. These are just a few of the many opportunities and/or issues with closed science that can be addressed through open science practices.

The advocacy for open science has been gaining steam throughout all scientific disciplines, however, there is very little literature on the topic for exercise science. This narrative review has the goal of identifying, examining, and analyzing the need for, plausibility and consequences of the implementation of open science practices in exercise science research. The purpose of this article is to bring attention to the field of exercise science which is in need of open data policies but is not often studied for such.

2 Issues and Opportunities Common to Closed Science in Exercise Science Research

2.1 Lack of Preregistration

Preregistration is the process by which researchers catalog their outcomes, results, and other relevant methodological information prior to conducting their study. Preregistered studies promote the open science principle of transparency. As it stands now, there is a large lack of knowledge as to how several studies evolved into what they became. With preregistration however, the differences between the initial research and the finished product are put on display. If more studies were preregistered, then the quality and validity of any given study would be much easier to assess. Preregistration also allows for the easier discovery of misconduct in research due to the ability to view said differences. It should be noted however that variance between a preregistered study and the final publication does not always mean a form of misconduct has occurred. At many points during research, changes in eligibility criteria, methodology, and other aspects of the study may be inevitable. As long as these changes are logged via

updates to the preregistration, ethical changes should be a non-issue. Preregistration provides clarity to readers and researchers, however, not all studies supply this luxury.

Concern about the negative effects of preregistration is not uncommon, especially in regard to exploratory research. A major concern is raised as to whether or not pre-registration discourages exploratory research. Although research of any kind conducted in an ethical manner should not be discouraged, our judgment should not be clouded in believing that studies which veer off their original path are as strong as those that are pre-registered, created for the express purpose of determining a specific outcome, and follow through on those promises. That is not to say that exploratory research is not useful or needed because it is. However, the claim that a world of vast pre-registration will discourage exploratory research should be a testament to the difference in the strength of evidence provided by the two. In an ideal world, there is no need for exploratory research because everything goes according to plan, however this is simply not the case. Exploratory research is equally important and necessary to the furthering of scientific knowledge, however, it should not be held to the same standard as pre-registered studies that follow through on their promises. Additionally, the greater issue with exploratory research is not so much the changing and discovering of new ideas, but the closedness of the process. If these studies were initially preregistered and the preregistration was changed as they alter the study (with all the change logs available), which is already an option on clinicaltrials.gov (“How to edit,” n.d.), then the openness of the process would inherently boost the study’s credibility. Pre-registration is more asking for an open view of process, not the need to stick to the original idea 100% of the time.

The consensus on preregistration is mixed. In a small survey of 181 editorial board members for the *Journal of Consumer Research* and *Journal of Consumer Psychology* regarding their opinions on preregistration, 24% of respondents were moderately to strongly opposed while 25% were moderately to strongly in favor (Pham & Oh, 2021). When asked whether “preregistration should be mandated for empirical consumer research” 90.6% of respondents answered “no”. The reasoning for which “no” was selected varied between respondents. 30% of respondents raised the concern that the preregistration system could be “easily gamed” (Pham & Oh, 2021). Considering it costs both time and money to preregister a study, it would be a waste of resources for said practice to be mandated but be easily manipulated. Although it may be true that preregistration can be gamed, the purpose of the open science movement is to cultivate an environment in which manipulating the system will be no more beneficial than following the proper protocol. In shifting towards an environment where negative results are published equally to positive results (see section 2.3), manipulating the preregistration system would be a waste of resources and incredibly unethical. 17% of the survey respondents that selected “no” noted the importance of exploration while another 13% mentioned a loss of flexibility due to the introduction of mandatory preregistration policies (Pham & Oh, 2021). While these are of valid concern, the ability to edit a preregistered study is already available on clinicaltrials.gov. No loss of flexibility or exploration should be experienced if there is the ability to edit the preregistration. On the clinicaltrials.gov website, each change to a study’s preregistration is noted and logged (“How to edit,” n.d.). Open science is calling for greater transparency in research. Exploration should not be discouraged, however, it should be noted if outcomes, methods, eligibility criteria, etc change.

Even though studies may be preregistered, poor attention to detail can cause confusion among readers. For example, when comparing the preregistered study titled “*The Back Exercises to Neutralize Disability Study (BEND)*” to its only linked final publication via [ClinicalTrials.gov](https://clinicaltrials.gov), “*Effectiveness of blood flow restricted exercise compared with standard exercise in patients with recurrent low back pain: study protocol for randomized controlled trial*,” there was a glaring issue. The eligibility criteria were different among the two (Amano et al., 2016; “The back,” n.d.). Considering the criteria for both should be the same, this was an interesting discovery. Because of this, an author of the study was reached out to for an

explanation. According to them, the eligibility criteria for the preregistration had been updated for their full study titled “*Blood Flow–restricted Exercise Does Not Induce a Cross-Transfer of Effect: A Randomized Controlled Trial*,” however, at the time of writing, this study was not linked to the updated preregistration (“The back,” n.d). This presents an obvious problem in that there is no linkage between the full published study and the preregistration through the ClinicalTrials.gov website. Although the full study notes the preregistration and provides the correct ClinicalTrials.gov identifier (Ampomah et al., 2019), the lack of transparency through the ClinicalTrials.gov website is alarming.

Although many reservations are had about mandatory preregistration, its implementation would lead to much more transparency and therefore encourage the greater use of more ethical and credible practices. While the concerns coming from researchers about mandatory preregistration are valid, the massive potential upside must be considered. Mandatory preregistration has the potential to greatly increase the transparency, credibility, and replicability of exercise science studies.

2.2 Non-disclosure of Raw Data

Raw data is data that has been collected for a research study that has not yet been transformed or analyzed for study use (McIver, 2008). There are quite a few benefits to disclosing one’s raw data. For one, this would allow for much easier comparison whilst replicating a study. Instead of relying on purely statistical measures such as mean and standard deviation, the actual raw data points can be compared. Additionally, statistical misconduct of any kind can be found much easier with a raw data set. Inherently, this would discourage the use of shady statistical practices and aid in cultivating a more honest research environment.

Although a multiple field-spanning issue, the non-disclosure of raw data in research is common among exercise science studies. In each of the preregistered exercise science studies utilized for the purpose of this review, none of them disclosed their raw data (“Aerobic exercise,” n.d.; “Efficacy study,” n.d.; “Exercise in,” n.d.; “The back,” n.d.). Each study did however provide some form of statistical analysis that was related to an outcome that was studied. A glaring issue with this is the lack of possibility for validation and replicability even within preregistered studies (Miyakawa, 2020).

A major concern of researchers may be the potential for others to “steal” their work due to the raw data being available. Although in a system where the disclosure of raw data is required, researchers would have to submit their raw data prior to any statistical analysis; this raw data set would not be made public until after their study is published. Additionally, although the raw data is made public, this does not mean others are given the right to publish their own study solely based off of that data set. The purpose of the disclosure of raw data is to increase the replicability of studies and prevent statistical misconduct. Those who base their own study on a data set that they did not collect and/or were not given permission to use should be discouraged and punished. Other concerns arise from the extra time it takes to deidentify, tidy up and/or reformat a data set. Although this is a valid concern, if a universal format for raw data sets were created, then the data would be logged with this already in mind, thus cutting down on much of the time concern. In other words, the extra time it would take to change an already logged raw data set would be eliminated due to the fact that it would be tidied and logged in the correct format from the beginning of data collection.

Whilst policy would need to be implemented to clean up potential issues researchers may have with the mandatory disclosure of raw data, it is difficult to argue that it wouldn’t benefit the advancement of exercise science research.

2.3 Publication Bias and The File Drawer Effect

Publication bias is defined as “the failure to publish the results of a study on the basis of the direction or strength of the study findings” (DeVito & Goldacre, 2019). In both exercise science and all scientific literature as a whole, favoritism appears to be given to studies with positive results. Research shows studies with positive results have a two-and-a-half times greater chance of getting published versus those with negative results (Dickersin & Chalmers, 2011). Additionally, studies with negative results tend to take longer to appear in print when compared to their positive result counterparts (Dickersin & Chalmers, 2011). The favoritism given to studies with positive results is detrimental to the furthering of scientific information as the knowledge of what does not work is inherently as important as knowing what does. Publication bias seems to stem from two main sources: the publisher and the researcher.

The most obvious of the two barring forces to publication is the publisher. Oftentimes, big publishers are seeking out the next biggest revelation in science and one that can catch the eye of the reader. This ultimately leads to more sales and thus more money. Although studies with negative results are just as important as those with positive ones, they are often pushed to the side in lieu of the flashier articles. The lack of willingness to publish studies with negative results then leads to what is known as the “file drawer effect.”

The knowledge that publishers will have a less likelihood of publishing negative results may lead to researchers hiding this data away in their “file drawers” for it to never see the light of day, hence the name “the file drawer effect” (Nagarajan et al., 2017). The issue is so drastic, that it is believed that for every study published with a significant result, there are 19 unpublished studies with non-significant results (Praveen et al., 2016). Publishers may not always be the driving force behind the file drawer effect however. There are many other reasons why researchers may not present their results for publication such as those challenging a generally accepted idea. In some of these cases, the presenting of data that challenges very established research could be viewed as career suicide. Regardless of the reason however, incomplete reporting can result in either under or overestimation of study results (Dickersin & Chalmers, 2011) which has the ability to reinforce an academic echo chamber on a given topic.

The favoritism given to studies with positive results may influence the findings of what is now regarded as the most objective research method: the meta-analysis. With the number of studies with negative results that have gone unpublished, it would be reasonable to conclude that many meta-analyses on any topic have and will result in a biased answer. A question must be raised as to how “objective” meta-analyses are in exercise science research due to the negative effects of publication bias and incomplete reporting.

Publication bias is an incredibly difficult issue to remedy. Public advocacy has only gone so far, so there must be a call to action for both publishers and researchers. If studies are to be mandatorily preregistered with their results posted, then there would be no secret as to how many studies have negative results that remain unpublished. This may positively pressure researchers to attempt to publish their results as the negative results of their study will already be made public. At this point, it would be a waste of a study to not attempt to publish it considering the results can already be accessed. As for the publishing companies, there must be a push for equal reporting of positive and negative results. Whether that is accomplished by researchers pushing for more of their studies with negative results to be published or mandates that require publishers to seek out a more even split of study results, the issue of publication bias must be formally addressed.

2.4 Outcome Switching

Outcome switching is the practice of swapping out objectives that were previously defined with new ones in the published study (Warrier & Jayanthi, 2022). All studies set out with an initial goal in mind and if that goal is not reached, some researchers may pick out certain parts of the data to fit a new objective. An obvious example can be seen in the preregistration titled “Exercise in Lessening Fatigue Caused by Cancer in Patients Undergoing Chemotherapy (EXCAP).” In this preregistration, the only outcome listed is “Change of Cancer-related Fatigue as Assessed by the Brief Fatigue Inventory (BFI)” (“Exercise in,” n.d.). Per the results listed on the preregistration, exercise’s effects on cancer-related fatigue were found to be statistically insignificant (“Exercise in,” n.d.). Most likely due to this mishap, the study authors went on to publish 3 studies utilizing the data collected in this study, but instead with regards to peripheral neuropathy, a positive result, and not fatigue (Kleckner et al., 2017; Kleckner et al., 2019; Kleckner et al., 2021).

Issues arise with outcome switching in that these studies may have less reliable evidence. If a particular study did not initially have the published outcome in mind, the certainty of the eligibility criteria used, thoroughness of the cherry-picked data, and overall methodology must be questioned. If the methods and data of the published study were not created/collected with the final outcome in mind, it would be reasonable to assume that much more reliable studies are possible as they would operate under more specific constraints.

Those in favor of the practice of outcome switching usually argue the point that research should be exploratory in nature and not just adhere to pre-study guidelines. To this, it should be acknowledged that there should be no issues with the practice if the switching is documented and available for others to see. This feeds back into the prior point that studies built on the foundation of a specific outcome will likely produce more credible results when compared to an outcome studied as an effect of the data produced. The reader should have the right to know whether or not the outcome was predetermined or not.

The practice of outcome switching is one that is largely fueled by the issue of publication bias. If there were no bias toward positive results, then there would be little to no reason for scrapping an outcome as a whole. Although it is imperative that other important results that are discovered that were not intended are explored and reported, original outcomes should not be scrapped for publication in lieu of collateral positive results such as what was seen in the study previously mentioned. The issues of outcome switching and publication bias raise the question as to how many researchers may waste their time and money researching an outcome that has already been studied but was never made public. Perhaps the only way to prevent this practice is to work towards the elimination of the negative results narrative.

2.5 Unclear Method Reporting

In health and wellness research, which encompasses exercise science, evidence is oftentimes presented for the purpose of suggesting efficacy (Tiller et al., 2022). Subsequently, these studies tend to be of poorer quality and are largely subjected to a greater risk of methodological bias (Heneghan et al., 2012). This is especially apparent in the sports performance world where studies are produced in an attempt to justify the purchase of performance products. In a 2012 study on sports performance research, only three of the 74 (4.1%) research articles studied provided enough detail to label them as having a low risk of bias and being high-quality research (Heneghan et al., 2012). It is imperative that exercise science and sports medicine studies report their methods fully and clearly, something that is not currently required.

Open methodology “refers to [the] opening up of research methods that are used in order to conduct experiments and reach reproducible scientific conclusions” (Chakravorty et al., 2022). In some cases, current methodology reporting may leave readers and researchers questioning the overall quality and credibility of a study. Methodological biases may be present in studies that are unable to be determined due to the lack of detail in the methods section. There are plenty of guidelines for exercise science researchers to follow via the EQUATOR Network, however, in some cases, the complexity of an exercise intervention may not be described well enough with the reporting methods suggested by EQUATOR (Slade et al., 2016). Clearer method reporting allows for the more precise replication of studies. A great barrier for those looking to replicate studies lies within the pure inability to find the detailed methods used to carry out the research. Perhaps a shift towards a more detailed guideline for exercise science studies such as the CERT model for reporting exercise interventions will lead to better reporting and replication of studies in the field (Slade et al., 2016).

Concerns have been raised about open methodology. For one, a more detailed methodology section means more time and money spent. Another major concern is the possible theft of scientific data arising from open methodology, however, solutions to this issue have been determined such as the implementation of “internet-based platforms with proper time-stamps” (Chakravorty et al., 2022). Although the requirement of researchers to log their full, in-depth methodology in both their preregistration and final published study may be slightly more time-consuming, it would have an immensely positive impact on the transparency and ability to replicate exercise science research.

2.6 Limited Access to Published Studies

Access to academic journals is not free or cheap. Many of these journals come in at a price point that many institutions and researchers around the world lack the funds for (Chakravorty et al., 2022). Although publishers need to make money, the gatekeeping of scientific knowledge behind an unnecessarily expensive paywall is unjustified with the amount of profit many of the large publishers generate. 50% of the worldwide research products are published by just four publishing companies; those being Taylor & Francis, Wiley-Blackwell, Springer, and Elsevier (Meadowcroft, 2020). Each of these companies are “for-profit” businesses, which is reasonable considering most companies are built on the foundation of generating money. However, the extent to which many of these publishers push their profit margins rides the line of unethical and immoral. For example, in 2018 Springer Nature ran at a 23% profit margin, while Elsevier ran at 37% (Aspesi, 2019). Elsevier alone has a greater profit margin than some of the most profitable companies in the world including Apple, Microsoft, Google, and Bank of America (“20.13%,” n.d.; “22.99%,” n.d.; “29.07%,” n.d.; “31.14%,” n.d.). It stands to reason that access to publications could be cheaper as there is plenty of profit to spare. It is unethical for these large publishers to bar low-income nations and individuals from scientific information that could otherwise be accessed at a lower cost or potentially even for free. As it stands now, if researchers want to provide open access (free access) to their study in a renowned journal, the researcher must bear the burden of a large open-access fee. These fees may be too costly for many researchers to afford. Considering the profit margin at which many of these large publishers are operating, it is hard to justify both these exorbitant fees and the price point at which readers pay for the articles.

There are many challenges to the open access of publication, however, that should not prevent the motion toward a solution. The greatest challenge to providing free or low-cost research articles to the public is also the most obvious: money. Those challenging the idea of open access will be quick to bring up the fact that the process of publishing and storing articles is not free. Publishing companies must pay their employees, building costs, database costs, etc. Although truly free access to research may not be able to be realistically implemented, there is no reason it cannot be cheaper. The money is most definitely there

at least. As mentioned prior, the top research publishing companies enjoy massively exorbitant profit margins, so a decrease in price is a very realistic possibility. Problems arise however in the demand for lower-cost articles. Demanding a lower price for research articles is incredibly difficult without governmental economic intervention. There are other routes to go about this issue however. For example, a solution that benefits the researcher, reader, and minimizes profit losses on behalf of the publisher is the “green open access model.” In this model, journals and publishers would allow authors to archive their published studies for open access on a third-party website (Chakravorty et al., 2022). The caveat is that the publishers and journals have the right to bar the author from separately uploading their final accepted version of their study to the third-party website. Additionally, the publishers and journals would be able to enforce an embargo period that prevents the author from immediately uploading their study for open access (Chakravorty et al., 2022). Although this model is far from true open access, it is a realistic step in the right direction. Authors benefit greatly from this model as they are able to circumnavigate the large open-access fees charged by publishers while still providing their study for free to readers. The readers benefit as well as they would gain access to even more free publications. Although the publications may not be available right away or may not be the final accepted version, the studies provided will still be useful to those who are unable to pay the original price for articles. Lastly, the publishers and journals still hold the upper hand on what gets published and what does not. They can still have leverage by being in possession of the final accepted paper, and therefore the most “up-to-date” publication. Additionally, the embargo period that they may enforce will require readers to pay for the article if they want the most up-to-date information as soon as possible. Although true open access is difficult to accomplish and may even be impractical, realistic mid-way solutions such as the green open access model should be considered and implemented for the betterment of scientific advancement in exercise science research.

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