 doi:10.20944/preprints202210.0124.v1

Communication

Short Communication: Could the Skin Microbiome Affect Sports Recovery And Performance?

Christopher Wallen-Russell [1,*] **and Samuel Wallen-Russell** [1]

[1] The Skin Microbiome School, Pavane Research Centre, Reading, Berkshire RG1 4QD, UK
* Correspondence: kit@microbiomeschool.com

Abstract: This short communication reports on the initial results of a much larger, ongoing project, the aim of which is to investigate the question: could the skin microbiome, just like the gut microbiome, play a role in sports recovery and performance – and if so, could this role be as significant a one as that played by the gut microbiome? 17 high performance college athletes addressed their skin microbiome by minimizing contact with synthetic chemicals and by using topical skin supplements, shown previously to significantly increase skin microbiome biodiversity, for two weeks after training. 76% said their skin softness improved, 35% said their muscle stiffness and recovery after sport improved, 12% said their sleep quality improved, and 100% said they would be likely to use skin supplements again. Future work will use hundreds of athletes.

Keywords: microbiome; skin microbiome; sports recovery; sports performance; cosmetics;

1. Introduction

This short preliminary study aimed to start answering the big question that underpins our ongoing project: could the skin microbiome, just like the gut microbiome, play a role in sports recovery and performance – and if so, could this role be as significant a one as that played by the gut microbiome? This short communication details the results from a small study testing this hypothesis on a group of 17 high performance college athletes who used skin microbiome enhancing methods including topical skin supplements for two weeks after training.

Multiple studies have shown that a healthy, biodiverse gut microbiome is crucial for sports recovery and performance because it is thought to impact muscle growth [1,2], boost energy levels [3,4], strengthen bones [5], reduce inflammation [6], and improve sleep [3,7].

However, to the best of our knowledge, there have been no studies on how the skin microbiome affects sports recovery and performance. This disparity should be addressed because the skin and gut microbiome are intrinsically linked by what is referred to as the 'gut-skin axis' [8–11], and it is fast becoming evident that the skin might be just as important as the gut for whole body health. For example, research is now suggesting that gut problems such as food allergies could now originate from a damaged skin microbiome [12–14].

The ecosystem in and on our body, the microbiome, is incredibly important for whole body health. A damaged gut microbiome, low in biodiversity, has been linked with a large number of internal problems from IBS and food allergies to intestinal infections. A depleted skin microbiome has also been linked with all common skin problems [12,15–21]. However, the body is a complex, interlinked system, and as an integral part of the immune system, the microbiome is now thought to be crucial for protecting against whole body, systemic problems, not just those in the immediate vicinity of the skin or gut [12,22–24].

2. Materials and Methods

 doi:10.20944/preprints202210.0124.v1

This preliminary study involved 17 human participants from America, all of whom are high performance college athletes on scholarships. The study length was two weeks, and during this time the participants used skin microbiome strengthening methods after training. The first step was to minimise contact with synthetic ingredients in cosmetics and the environment, and secondly, they used a topically applied skin supplement shown in previous work to significantly increase the biodiversity of the skin microbiome. They were told to keep everything else about their regime the same, such as diet and training frequency.

The participants were made aware of the conditions at the beginning; this included filling out a questionnaire at the start and the end of the study in order to track progress and to obtain some preliminary results. The questionnaires only contained questions with set, binary answers to choose from, which meant that answers were not personal.

All participants provided informed verbal consent prior to enrollment in the study. Results and questionnaire answers from this study cannot be linked to a specific individual due to anonymous reporting and data handling. The process was agreed on by the Pavane Research Centre in the U.K.: they stated that no ethical concerns were raised by the methods applied and approved the procedures in this study.

2.1. Skin Microbiome Intervention

For the two-week study period, the athletes were first told to minimise contact of their bodies with synthetic chemicals, whether that was from cosmetics products, cleaning products, or in the environment. Next, they were instructed to use skin supplements that were shown in previous work to significantly increase the biodiversity of the skin microbiome [25,26]. These were a 100% natural face and body wash, the information about which can be found in previous work which describes its effect on the skin microbiome. The guidelines for use of the product for the skin are listed below:

- Use the product on the skin at least 1× per day after exercise. This could include showering and washing throughout the day too.
- To use the product, mix with a small amount of water to form a solution, and gently massage onto the body.
- Minimise use of other cosmetics products as much as possible. This may not always be possible if, for example, one needs to wear makeup for an important business meeting.
- In the beginning, introduce the product slowly to the body by using it mixed with a small quantity of water in small amounts and build up to larger amounts as time goes on.

Why did we choose this method? When discussing possible microbiome enhancing solutions, it is common that 'Probiotics' are immediately mentioned. Virtually unheard of in comparison to those for the gut [27–30], topical probiotics have huge potential for reversing the catastrophic biodiversity loss on our skin [31,32]. However, previous research has warned that at current levels of skin microbiome knowledge, where every human possesses a 'virtually unique' microbiome [33–35], it is extremely difficult to implement a safe and effective probiotic solution [31]. It could potentially disrupt the delicate microbiome balance and reduce biodiversity. In support of this, previous work has warned against improper implementation [36], that side effects [28,37] and unsubstantiated therapeutic claims are a concern [28,38], and that universal health benefits do not exist [39].

With probiotics, prebiotics and postbiotics for the skin still needing much research, we wanted to try and re-create the skin's natural environment and allow biodiversity to thrive. A first step would be to take away some deleterious factors, here synthetic ingredients in everyday cosmetics, in the western environment thought to be a major contributor to biodiversity loss on the human microbiome [40]. The next step would be to try and enhance the skin microbiome by actively increasing its biodiversity; this is where the skin supplements were brought in. As healthier skin is characterized by an increase in biodiversity [7], this intervention could also have influenced skin condition.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 10 October 2022 doi:10.20944/preprints202210.0124.v1

2.2. Data Analysis

Each participant filled out a questionnaire at the beginning and end of the study period. The pre-programme questionnaire was used to evaluate the participants' awareness of issues such as the importance of the microbiome for whole body health. Microsoft Excel was used to turn the answers into the tables and charts seen in Section 3. The questions included are below:

2.2.1. Pre-Programme Questionnaire

"Are you aware of research that shows…:" (Options 'Yes' 'No', and 'Not Sure' were available)

- For post-exercise muscle growth, a strong Microbiome (ie. 'good bacteria' living in our body) is essential?
- Most people living in the developed (Western) world have a damaged Microbiome?
- For Whole Body Health & Fitness, the Skin Microbiome could be just as important as the Gut?
- Everyday shower products (inc. soap & shower gel) usually contain synthetic chemicals that damage the Microbiome?

Review Section

- Do you currently take any Sports Supplements?
- Do you regard Sports Supplements as crucial for both Recovery and Fitness?
- Do you take Sports Supplements to help your Gut Microbiome?
- Would you use Sports Supplements for the skin to help your Skin Microbiome?

2.2.2. Post-Programme Questionnaire

The first 4 of the following questions gave the the options 'Improved', 'Stayed The Same', or 'Got Worse'.

- Has your skin softness…
- Has your sleep quality…
- Has your recovery from muscle stiffness/soreness...
- Has your confidence…
- If you previously had skin problems, have these changed at all?
- Did you reduce the use of other cosmetics/products during the study?

3. Results

3.1. Pre-Programme Knowledge And Awareness

A questionnaire was filled out by all 17 participants at the start of the two week trial period which allowed us to assess their awareness of the microbiome for sports recovery and whole body health. The results are shown in Table 1, Table 2, Figure 1 and Figure 2.

Table 1. The awareness questions from the first section of the 'Pre-Programme Questionnaire, including the percentage of people who chose each answer.

"Are you aware of research that shows…:"	**Yes**	**No**	**Not Sure**
For post-exercise muscle growth, a strong Microbiome (ie. 'good bacteria' living in our body) is essential?	53%	47%	-
Most people living in the developed (Western) world have a depleted Microbiome?	53%	47%	-
For Whole Body Health & Fitness, the Skin Microbiome could be just as important as the Gut?	59%	41%	-
Everyday shower products (inc. soap & shower gel) usually contain synthetic chemicals that can damage the Microbiome?	76%	24%	-

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 10 October 2022 doi:10.20944/preprints202210.0124.v1

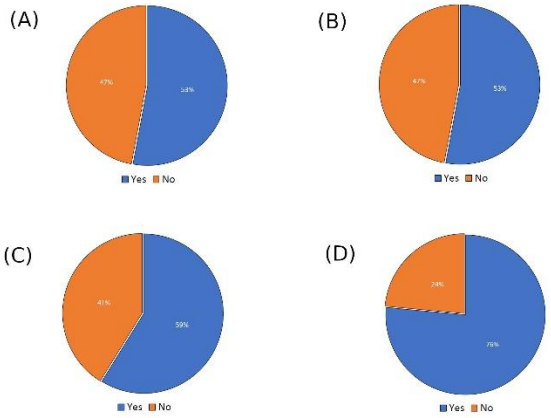

Figure 1. Circle charts to display results to the questions in Table 1. A) For post-exercise muscle growth, a strong Microbiome (ie. 'good bacteria' living in our body) is essential? B) Most people living in the developed (Western) world have a depleted Microbiome? C) For Whole Body Health & Fitness, the Skin Microbiome could be just as important as the Gut? D) Everyday shower products (inc. soap & shower gel) usually contain synthetic chemicals that can damage the Microbiome? Blue sections represents the percentage of people who answered 'Yes' and orange sections represent 'No'.

Table 2. The final questions from the first section of the 'Pre-Programme Questionnaire, including the percentage of people who chose each answer.

Final questions	**Yes**	**No**	**Not Sure**
Do you currently take any Sports Supplements?	18%	76%	6%
Do you regard Sports Supplements as crucial for both Recovery and Fitness?	35%	35%	29%
Do you take Sports Supplements to help your Gut Microbiome?	0%	94%	6%
Would you use Sports Supplements for the skin to help your Skin Microbiome?	71%	6%	24%

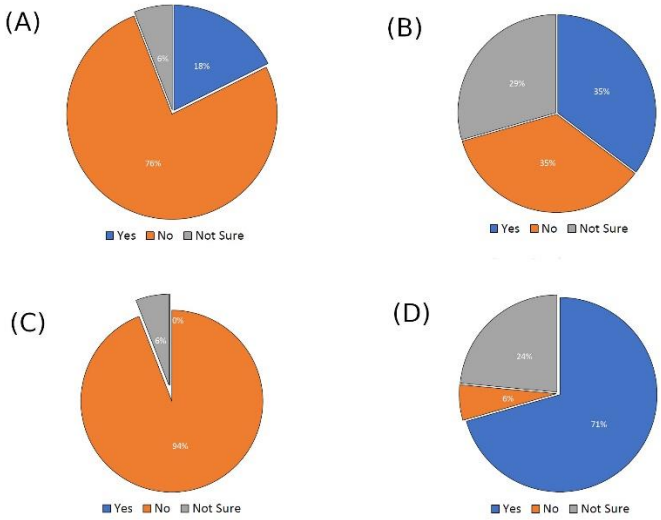

Figure 2. Circle charts to display results to the questions in Table 2. A) Do you currently take any Sports Supplements? B) Do you regard Sports Supplements as crucial for both Recovery and Fitness? C) Do you take Sports Supplements to help your Gut Microbiome? D) Would you use Sports

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 10 October 2022 doi:10.20944/preprints202210.0124.v1

Supplements for the skin to help your Skin Microbiome? Blue sections represent the percentage of people who answered 'Yes', orange sections represent 'No' and grey represents 'Not Sure'.

3.1. Post-Programme Results

Figure 3, Table 3, Figure 4 and Table 4 show the results from the post programme questionnaire after the two week study had taken place. 76% said their skin softness improved (Figure 3.a.), 35% said their muscle stiffness and recovery after training improved (Figure 3.b.), 12% said their sleep quality improved (Figure 3.c.), and 29% said their confidence improved

Table 3. The final questions from the first section of the 'Pre-Programme Questionnaire, including the percentage of people who chose each answer.

Final questions	**Improved**	**Stayed The Same**	**Got Worse**
Has your skin softness…	76%	24%	-
Has your sleep quality…	12%	88%	-
Has your recovery from muscle stiffness/soreness...	35%	65%	-
Has your confidence…	29%	65%	6%

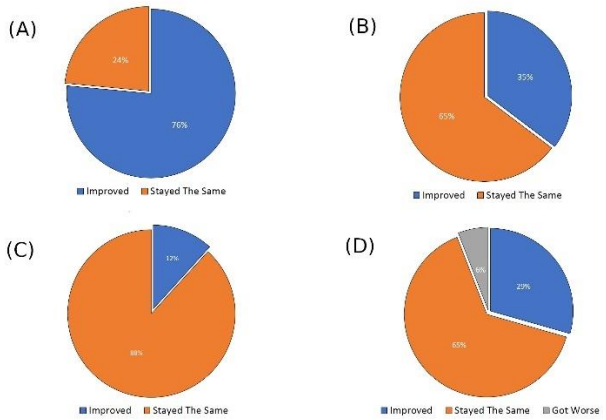

Figure 3. Circle charts to display results to the questions in Table 3. A) Skin softness B) Muscle Stiffness and recovery C) Sleep quality D) Confidence. Blue sections represent the percentage of people who answered 'Improved', orange sections represent 'Stayed The Same' and grey represents 'Got Worse'.

Table 4. The final questions from the first section of the 'Pre-Programme Questionnaire, including the percentage of people who chose each answer.

Final Questions	**Yes**	**No**	**Not Sure**
If you previously had skin problems, have these changed?	27%	73%	-
Did you reduce the use of other cosmetics/products during the study?	88%	12%	-
Would you be likely to use skin supplements for sports recovery in the future?	100%	0%	-

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 10 October 2022 doi:10.20944/preprints202210.0124.v1

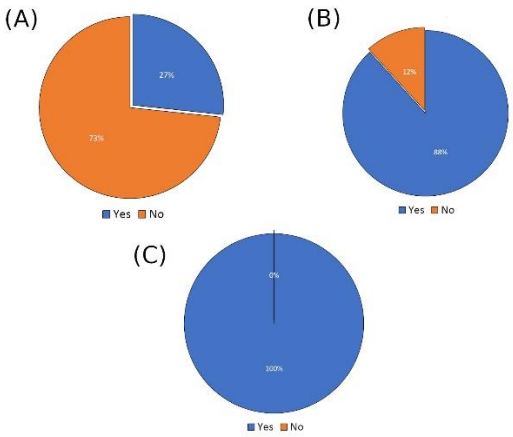

Figure 4. Circle charts to display results to the questions in Table 4. A) If you previously had skin problems, have these changed? B) Did you reduce use of cosmetics during the study? C) Would you be likely to use skin supplements for sports recovery in the future? Blue sections represent the percentage of people who answered 'Yes', orange sections represent 'No' and grey represents 'Not Sure'.

4. Discussion

4.1. Physical Results

35% of participants said they noticed an improvement in their muscle stiffness and recovery after sports while doing the study. As previously mentioned, a healthy gut microbiome has been shown to benefit many factors that are involved in sports performance and recovery [1–3,5,7,41–43]. We also note that the same is true in reverse; exercise has been shown to strengthen the gut microbiome and increase biodiversity [4]. However, the skin's effect has barely been researched. New research is showing that the skin microbiome could be just as important for whole body health as the gut. The gut-skin axis [8–11], which describes how the two ecosystems are intrinsically linked, suggests that the skin microbiome could also play an integral role in sports recovery. Therefore, the 76% improvement in perceived skin softness should be further analysed in future work to see if it correlates to an increase in biodiversity which may impact sports performance and recovery.

Another question to answer in the future would be: could addressing both skin and gut microbiomes simultaneously impact sports recovery and performance (and other whole body health issues) more than addressing the two in isolation [44]? As the first line of defence, the skin has a much more direct exposure to potentially harmful agents in the western environment than the gut.

An important part of sports recovery and performance is sleep quality, which is thought to increase reaction time, accuracy, and endurance performance [45]. 12% of participants in this study said they felt their sleep quality improved. Previous studies have shown how a 'dysbiotic' gut microbiome, low in biodiversity, is associated with poor sleep [7] and how it affects melatonin production which is essential for proper sleep-wake cycles [3]. Could the skin microbiome affect sleep quality too?

Previous studies have reported that confidence can play a significant role in performance for athletes [46,47]. It could be one of many factors that give small overall percentage gains but for high-performance athletes, it is often the marginal gains which could be the difference between winning and losing. 29% of athletes in this study said their confidence improved. Additional work has shown how skin health is related to confidence [48], so an improvement in skin softness in this study could also correlate to increased confidence. This relationship would need to be investigated in future work with a longer trial period.

 doi:10.20944/preprints202210.0124.v1

The skin health product used in this study was shown to significantly increase skin microbiome diversity in previous work [25]. Instead of introducing new microbes, it aims to create the right conditions on the skin for biodiversity to flourish [19,25]. As healthier skin is characterized by an increase in biodiversity [19], similar interventions could also have had an effect on skin condition. Coupled with reducing the use of other everyday cosmetics, this could have contributed to 76% of the participants seeing an improvement in skin softness in this study.

Significantly reducing the use of other cosmetics containing synthetic ingredients is also thought to be an integral part of re-storing the skin microbiome. Studies have explained how exposure of the skin to 21st century chemicals, such as those in modern cosmetics and steroids, is thought to have contributed to skin microbiome damage [19,25,35,40,49–55], which, while not confirmed, is suggested to be a major contributor to an 'allergy epidemic' in the western world [15,20,40,56–68].

4.2. Awareness and Education

A large part of this project is about awareness and education. Only just over half of the participants (53%) were aware of research detailing the positive effects of a healthy gut microbiome on sports recovery and performance, despite this being a much talked about area in academia and within mainstream sports teams. It follows that, as a much under-researched area in comparison, even fewer people would understand the need to keep the skin microbiome healthy for whole body health.

It is interesting that 76% understood that synthetic ingredients in every-day cosmetics could damage the microbiome, yet, before the two-week study, a large proportion used cosmetics with high levels of artificial additives. This disconnect could be because consumers are sometimes unaware of the amount of synthetic ingredients in their cosmetics, many of which are labelled natural. Previous work shows how even 'natural' products with images of flowers on them can contain 70%+ synthetic ingredients [25].

After completing the study, 100% of participants, up from 71% before the study, said they'd be likely to use skin supplements in their regime in the future. This could have arisen due to a mixture of awareness and the participants' experience with the methods used to address the skin microbiome during the study. This highlights the need for education on the crucial importance of the skin microbiome in whole body health.

4.3. Future Work

In future, this study will be extended to use a much larger sample size of hundreds of athletes who will address their skin microbiome for much longer than two weeks. Just like a health and fitness plan, improving the skin microbiome as part of a whole-body health plan is a long-term process, so it is likely that two weeks is too short to properly judge significance of results. If the skin microbiome has been damaged by use of everyday cosmetics containing synthetic ingredients for years beforehand, it is unlikely that it will be enhanced to healthy levels of biodiversity in just two weeks. Especially if there are multiple factors in the western world degrading the microbiome [19,25]. The gut and skin microbiomes of participants will be sequenced and analysed alongside an evaluation of changes in sports recovery and performance parameters such as muscle growth and inflammation.

5. Conclusions

This short preliminary study aimed to start answering the big question: could the skin microbiome, just like the gut microbiome, play a role in sports recovery and performance – and if so, could this role be as significant a one as that played by the gut microbiome? Methods to replace the lost biodiversity of the skin microbiome were used for two weeks. 76% of athletes said their skin softness improved, 35% said their muscle stiffness and recovery after sport improved, 12% said their sleep quality improved, and 100% said they would be likely to use skin supplements again. Due to the skin-gut axis, the complex, interlinked nature of the body, and new research highlighting the importance of skin health for whole body health, we believe the skin microbiome could play an important

 doi:10.20944/preprints202210.0124.v1

role in sports recovery and performance. However, much more research is needed. Future work will involve hundreds of athletes addressing their skin for longer and will include a full analysis of skin & gut microbiome and their effect on sports performance and muscle recovery parameters.

Funding: This research received no external funding

Institutional Review Board Statement: - NA -

Informed Consent Statement: - NA -
Data Availability Statement: - NA -

Acknowledgments: We would like to thank Linda Russell and Nick Wallen for their support, without whom our minds would not be broadened by our conceptual conversations. We would also like to mention that we used some library and information services of University College London (UCL) where the first author was an alumnus.

Conflicts of Interest: Christopher Wallen-Russell and Samuel Wallen-Russell are employees of research and development company Pavane Consultants Ltd. As license holder for the JooMo Ltd. range of skin health products, Pavane Consultants Ltd. is interested in determining how skin health can be measured and which environmental factors caused the huge increase in skin allergy problems in the past 75 years.

References

1. Lahiri S, Kim H, Garcia-Perez I, Reza MM, Martin KA, Kundu P, et al. The gut microbiota influences skeletal muscle mass and function in mice. Sci Transl Med [Internet]. 2019 Jul 7 [cited 2022 Oct 3];11(502). Available from: /pmc/articles/PMC7501733/

2. Valentino TR, Vechetti IJ, Mobley CB, Dungan CM, Golden L, Goh J, et al. Dysbiosis of the gut microbiome impairs mouse skeletal muscle adaptation to exercise. J Physiol [Internet]. 2021 Nov 1 [cited 2022 Oct 3];599(21):4845–63. Available from: https://onlinelibrary.wiley.com/doi/full/10.1113/JP281788

3. Jones RM, Neish AS. Redox Signaling Mediated by the Gut Microbiota. Free Radic Res [Internet]. 2013 Nov [cited 2022 Aug 31];47(11):950. Available from: /pmc/articles/PMC5131718/

4. Mach N, Fuster-Botella D. Endurance exercise and gut microbiota: A review. J Sport Heal Sci. 2017 Jun 1;6(2):179–97.

5. Krajmalnik-Brown R, Ilhan ZE, Kang DW, DiBaise JK. Effects of Gut Microbes on Nutrient Absorption and Energy Regulation. Nutr Clin Pract [Internet]. 2012 Apr [cited 2022 Oct 3];27(2):201. Available from: /pmc/articles/PMC3601187/

6. Pessione E. Lactic acid bacteria contribution to gut microbiota complexity: lights and shadows. Front Cell Infect Microbiol. 2012;2:86.

7. Anderson JR, Carroll I, Azcarate-Peril MA, Rochette AD, Heinberg LJ, Peat C, et al. A preliminary examination of gut microbiota, sleep, and cognitive flexibility in healthy older adults. Sleep Med [Internet]. 2017 Oct 1 [cited 2022 Aug 31];38:104–7. Available from: https://pubmed.ncbi.nlm.nih.gov/29031742/

8. Brandwein M, Katz I, Katz A, Kohen R. Beyond the gut: Skin microbiome compositional changes are associated with BMI. Hum Microbiome J. 2019 Aug 1;13:100063.

9. Salem I, Ramser A, Isham N, Ghannoum MA. The gut microbiome as a major regulator of the gut-skin axis [Internet]. Vol. 9, Frontiers in Microbiology. Frontiers Media S.A.; 2018 [cited 2021 May 25]. Available from: /pmc/articles/PMC6048199/

10. Ellis SR, Nguyen M, Vaughn AR, Notay M, Burney WA, Sandhu S, et al. The skin and gut microbiome and its role in common dermatologic conditions [Internet]. Vol. 7, Microorganisms. MDPI AG; 2019 [cited 2021 May 25]. p. 550. Available from: /pmc/articles/PMC6920876/

11. Pessemier B De, Grine L, Debaere M, Maes A, Paetzold B, Callewaert C. Gut–skin axis: Current knowledge of the interrelationship between microbial dysbiosis and skin conditions [Internet]. Vol. 9, Microorganisms. MDPI AG; 2021 [cited 2021 May 25]. p. 1–33. Available from: https://doi.org/10.3390/microorganisms9020353

12. Prescott SL, Larcombe D-L, Logan AC, West C, Burks W, Caraballo L, et al. The skin microbiome: impact of modern environments on skin ecology, barrier integrity, and systemic immune programming. World Allergy Organ J [Internet]. 2017 Dec 22 [cited 2018 Jul 18];10(1):29. Available from: http://waojournal.biomedcentral.com/articles/10.1186/s40413-017-0160-5

13. Lack G, Fox D, Northstone K, Golding J. Factors Associated with the Development of Peanut Allergy in Childhood. N Engl J Med [Internet]. 2003 Mar 13 [cited 2021 May 25];348(11):977–85. Available from: www.nejm.org

14. Čelakovská J, Bukač J. The severity of atopic dermatitis and analysis of the food hypersensitivity reactions. http://dx.doi.org/101080/0954010520151043622 [Internet]. 2015 Nov 2 [cited 2021 Oct 29];26(6):896–908. Available from: https://www.tandfonline.com/doi/abs/10.1080/09540105.2015.1043622

15. Kong HH, Oh J, Deming C, Conlan S, Grice EA, Beatson MA, et al. Temporal shifts in the skin microbiome associated with disease flares and treatment in children with atopic dermatitis. Genome Res [Internet]. 2012 May [cited 2017 Feb 21];22(5):850–9. Available from: http://www.ncbi.nlm.nih.gov/pubmed/22310478

16. Zaidi AK, Spaunhurst K, Sprockett D, Thomason Y, Mann MW, Fu P, et al. Characterization of the facial microbiome in twins discordant for rosacea. Exp Dermatol [Internet]. 2018 Mar [cited 2018 Jul 18];27(3):295–8. Available from: http://www.ncbi.nlm.nih.gov/pubmed/29283459

17. Velegraki A, Cafarchia C, Gaitanis G, Iatta R, Boekhout T. Malassezia Infections in Humans and Animals: Pathophysiology, Detection, and Treatment. Heitman J, editor. PLoS Pathog [Internet]. 2015 Jan 8 [cited 2018 Nov 12];11(1):e1004523. Available from: http://dx.plos.org/10.1371/journal.ppat.1004523

18. Manasson J, Reddy SM, Neimann AL, Segal LN, Scher JU. Cutaneous Microbiota Features Distinguish Psoriasis from Psoriatic Arthritis [abstract]. Arthritis Rheumatol [Internet]. 2016;68. Available from: https://acrabstracts.org/abstract/cutaneous-microbiota-features-distinguish-psoriasis-from-psoriatic-arthritis/

19. Wallen-Russell C, Wallen-Russell S. Meta Analysis of Skin Microbiome: New Link between Skin Microbiota Diversity and Skin Health with Proposal to Use This as a Future Mechanism to Determine Whether Cosmetic Products Damage the Skin. Cosmetics [Internet]. 2017 May 14 [cited 2017 Dec 19];4(2):14. Available from: http://www.mdpi.com/2079-9284/4/2/14

20. Wallen-Russell C, Wallen-Russell S. A new benchmark to determine what healthy western skin looks like in terms of biodiversity using standardised methodology. Cosmetics [Internet]. 2020 Dec 1 [cited 2021 May 20];7(4):1–19. Available from: www.mdpi.com/journal/cosmetics

21. Baviera G, Leoni MC, Capra L, Cipriani F, Longo G, Maiello N, et al. Microbiota in healthy skin and in atopic eczema. Biomed Res Int [Internet]. 2014 [cited 2018 Jul 18];2014:436921. Available from: http://www.ncbi.nlm.nih.gov/pubmed/25126558

22. Belkaid Y, Hand TW. Role of the microbiota in immunity and inflammation. Vol. 157, Cell. 2014. p. 121–41.

23. Zheng D, Liwinski T, Elinav E. Interaction between microbiota and immunity in health and disease [Internet]. Vol. 30, Cell Research. Springer Nature; 2020 [cited 2021 Jun 4]. p. 492–506. Available from: https://doi.org/10.1038/s41422-020-0332-7

24. Sanford JA, Gallo RL. Functions of the skin microbiota in health and disease. Semin Immunol [Internet]. 2013 Nov 30 [cited 2017 Dec 20];25(5):370–7. Available from: http://www.sciencedirect.com/science/article/pii/S1044532313000791?via%3Dihub

25. Wallen-Russell C. The Role of Every-Day Cosmetics in Altering the Skin Microbiome: A Study Using Biodiversity. Cosmetics [Internet]. 2018 Dec 27 [cited 2020 Jan 8];6(1):2. Available from: http://www.mdpi.com/2079-9284/6/1/2

26. Wallen-Russell C. Is There a Relationship between Transepidermal Water Loss and Microbial Biodiversity on the Skin? Cosmetics [Internet]. 2019 Mar 9 [cited 2019 Dec 17];6(1):18. Available from: https://www.mdpi.com/2079-9284/6/1/18

27. Knackstedt R, Knackstedt T, Gatherwright J. The role of topical probiotics in skin conditions: A systematic review of animal and human studies and implications for future therapies. Exp Dermatol [Internet]. 2020 Jan 1 [cited 2021 Sep 6];29(1):15–21. Available from: https://onlinelibrary.wiley.com/doi/full/10.1111/exd.14032

28. Lee GR, Maarouf M, Hendricks AJ, Lee DE, Shi VY. Topical probiotics: The unknowns behind their rising popularity. Dermatol Online J [Internet]. 2019 May 1 [cited 2021 Jul 16];25(5):5–6. Available from: https://escholarship.org/uc/item/2v83r5wk

29. Bustamante M, Oomah BD, Oliveira WP, Burgos-Díaz C, Rubilar M, Shene C. Probiotics and prebiotics potential for the care of skin, female urogenital tract, and respiratory tract. Folia Microbiol (Praha) [Internet]. 2020 Apr 1 [cited 2021 Aug 10];65(2):245. Available from: /pmc/articles/PMC7090755/

30. Knackstedt R, Knackstedt T, Gatherwright J. The role of topical probiotics on wound healing: A review of animal and human studies. Int Wound J [Internet]. 2020 Dec 1 [cited 2021 Sep 20];17(6):1687–94. Available from: https://onlinelibrary.wiley.com/doi/full/10.1111/iwj.13451

31. Wallen-Russell C, Wallen-Russell S. Topical Probiotics Do Not Satisfy New Criteria for Effective Use Due to Insufficient Skin Microbiome Knowledge. Cosmet 2021, Vol 8, Page 90 [Internet]. 2021 Sep 17 [cited 2021 Sep 23];8(3):90. Available from: https://www.mdpi.com/2079-9284/8/3/90/htm

32. Sharma G, Khanna G, Sharma P, Deol PK, Kaur IP. Mechanistic Role of Probiotics in Improving Skin Health. Probiotic Res Ther [Internet]. 2022 [cited 2021 Nov 27];27–47. Available from: https://link.springer.com/chapter/10.1007/978-981-16-5628-6_2

33. Ley RE, Lozupone CA, Hamady M, Knight R, Gordon JI. Worlds within worlds: evolution of the vertebrate gut microbiota. Nat Rev Microbiol [Internet]. 2008 Oct [cited 2017 Feb 20];6(10):776–88. Available from: http://www.nature.com/doifinder/10.1038/nrmicro1978

34. Pei Z, Bini EJ, Yang L, Zhou M, Francois F, Blaser MJ. Bacterial biota in the human distal esophagus. Proc Natl Acad Sci U S A [Internet]. 2004 Mar 23 [cited 2017 Feb 20];101(12):4250–5. Available from: http://www.ncbi.nlm.nih.gov/pubmed/15016918

35. Costello EK, Lauber CL, Hamady M, Fierer N, Gordon JI, Knight R. Bacterial Community Variation in Human Body Habitats Across Space and Time. Science (80-). 2009;326(5960).

36. Zmora N, Zilberman-Schapira G, Suez J, Mor U, Dori-Bachash M, Bashiardes S, et al. Personalized Gut Mucosal Colonization Resistance to Empiric Probiotics Is Associated with Unique Host and Microbiome Features. Cell [Internet]. 2018 Sep 6 [cited 2021 Sep 6];174(6):1388-1405.e21. Available from: http://www.cell.com/article/S0092867418311024/fulltext

37. Boyle RJ, Bath-Hextall FJ, Leonardi-Bee J, Murrell DF, Tang ML. Probiotics for treating eczema. Cochrane Database Syst Rev [Internet]. 2008 [cited 2021 Sep 20];(4). Available from: https://www.cochranelibrary.com/cdsr/doi/10.1002/14651858.CD006135.pub2/full

38. Great Healthworks, Inc. - 611686 - 06/23/2021 | FDA [Internet]. [cited 2021 Oct 12]. Available from: https://www.fda.gov/inspections-compliance-enforcement-and-criminal-investigations/warning-letters/great-healthworks-inc-611686-06232021

39. Kothari D, Patel S, Kim SK. Probiotic supplements might not be universally-effective and safe: A review. Biomed Pharmacother. 2019 Mar 1;111:537–47.

40. Blaser MJ, Falkow S. What are the consequences of the disappearing human microbiota? Nat Rev Microbiol [Internet]. 2009;7(12):887–94. Available from: http://dx.doi.org/10.1038/nrmicro2245

41. Hughes RL. A Review of the Role of the Gut Microbiome in Personalized Sports Nutrition. Front Nutr [Internet]. 2019 Jan 10 [cited 2022 Oct 3];6. Available from: /pmc/articles/PMC6966970/

42. Hsu YJ, Chiu CC, Li YP, Huang WC, Huang Y Te, Huang CC, et al. Effect of intestinal microbiota on exercise performance in mice. J Strength Cond Res [Internet]. 2015 Feb 1 [cited 2022 Oct 3];29(2):552–8. Available from: https://journals.lww.com/nsca-jscr/Fulltext/2015/02000/Effect_of_Intestinal_Microbiota_on_Exercise.33.aspx

43. Hughes RL, Holscher HD. Fueling Gut Microbes: A Review of the Interaction between Diet, Exercise, and the Gut Microbiota in Athletes. Adv Nutr [Internet]. 2021 Dec 1 [cited 2022 Oct 3];12(6):2190–215. Available from: https://academic.oup.com/advances/article/12/6/2190/6316456

44. Wallen-Russell C, Gijsberts-Veens A, Wallen-Russell S. Could Modifying the Skin Microbiome, Diet, and

Lifestyle Help with the Adverse Skin Effects after Stopping Long-Term Topical Steroid Use? Allerg 2022, Vol 2, Pages 1-15 [Internet]. 2021 Dec 24 [cited 2022 Aug 31];2(1):1–15. Available from: https://www.mdpi.com/2313-5786/2/1/1/htm

45. Watson AM. Sleep and Athletic Performance. Curr Sports Med Rep [Internet]. 2017 Nov 1 [cited 2022 Aug 31];16(6):413–8. Available from: https://journals.lww.com/acsm-csmr/Fulltext/2017/11000/Sleep_and_Athletic_Performance.11.aspx

46. Lochbaum M, Sherburn M, Sisneros C, Cooper S, Lane AM, Terry PC. Revisiting the Self-Confidence and Sport Performance Relationship: A Systematic Review with Meta-Analysis. Int J Environ Res Public Heal 2022, Vol 19, Page 6381 [Internet]. 2022 May 24 [cited 2022 Oct 3];19(11):6381. Available from: https://www.mdpi.com/1660-4601/19/11/6381/htm

47. Hays K, Thomas O, Maynard I, Bawden M. The role of confidence in world-class sport performance. https://doi.org/101080/02640410903089798 [Internet]. 2009 Sep [cited 2022 Oct 3];27(11):1185–99. Available from: https://www.tandfonline.com/doi/abs/10.1080/02640410903089798

48. Zhang XJ, Wang AP, Shi TY, Zhang J, Xu H, Wang DQ, et al. The psychosocial adaptation of patients with skin disease: A scoping review. BMC Public Health [Internet]. 2019 Oct 29 [cited 2022 Oct 3];19(1):1–15. Available from: https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-019-7775-0

49. Staudinger T, Pipal A, Redl B. Molecular analysis of the prevalent microbiota of human male and female forehead skin compared to forearm skin and the influence of make-up. J Appl Microbiol [Internet]. 2011 Jun [cited 2018 Jan 8];110(6):1381–9. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21362117

50. Rocha LA, Ferreira de Almeida e Borges L, Gontijo Filho PP. Changes in hands microbiota associated with skin damage because of hand hygiene procedures on the health care workers. Am J Infect Control [Internet]. 2009 Mar [cited 2018 Jan 8];37(2):155–9. Available from: http://www.ncbi.nlm.nih.gov/pubmed/19249642

51. Holland KT, Bojar R a. Cosmetics: what is their influence on the skin microflora? Am J Clin Dermatol. 2002;3(7):445–9.

52. Cogen AL, Nizet V, Gallo RL. Skin microbiota: a source of disease or defence? Br J Dermatol. 2009;158:442–55.

53. Belkaid Y, Segre JA. Dialogue between skin microbiota and immunity. Science (80-) [Internet]. 2014 Nov 21 [cited 2018 Jan 8];346(6212):954–9. Available from: http://www.ncbi.nlm.nih.gov/pubmed/25414304

54. Stingley RL, Zou W, Heinze TM, Chen H, Cerniglia CE. Metabolism of azo dyes by human skin microbiota. J Med Microbiol [Internet]. 2010 Jan 1 [cited 2018 Jan 8];59(1):108–14. Available from: http://www.ncbi.nlm.nih.gov/pubmed/19729456

55. Turnbaugh PJ, Ley RE, Hamady M, Fraser-Liggett CM, Knight R, Gordon JI. The Human Microbiome Project. Nature [Internet]. 2007 Oct 18 [cited 2018 Jan 8];449(7164):804–10. Available from: http://www.ncbi.nlm.nih.gov/pubmed/17943116

56. Goossens A. Contact-allergic reactions to cosmetics. J Allergy [Internet]. 2011 [cited 2017 Feb 21];2011:Article ID

467071. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21461388

57. Salverda JGW, Bragt PJC, de Wit-Bos L, Rustemeyer T, Coenraads PJ, Tupker RA, et al. Results of a cosmetovigilance survey in The Netherlands. Contact Dermatitis [Internet]. 2013 Mar [cited 2017 Feb 21];68(3):139–48. Available from: http://www.ncbi.nlm.nih.gov/pubmed/23421458

58. Heisterberg M V., Menné T, Johansen JD. Contact allergy to the 26 specific fragrance ingredients to be declared on cosmetic products in accordance with the EU cosmetics directive. Contact Dermatitis [Internet]. 2011 Nov [cited 2017 Feb 21];65(5):266–75. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21943251

59. Warshaw EM, Buchholz HJ, Belsito D V., Maibach HI, Fowler JF, Rietschel RL, et al. Allergic patch test reactions associated with cosmetics: Retrospective analysis of cross-sectional data from the North American Contact Dermatitis Group, 2001-2004. J Am Acad Dermatol [Internet]. 2009 Jan [cited 2017 Feb 21];60(1):23–38. Available from: http://www.ncbi.nlm.nih.gov/pubmed/18992965

60. Berne B, Tammela M, Färm G, Inerot A, Lindberg M. Can the reporting of adverse skin reactions to cosmetics be improved? A prospective clinical study using a structured protocol. Contact Dermatitis [Internet]. 2008 Apr [cited 2017 Feb 21];58(4):223–7. Available from: http://www.ncbi.nlm.nih.gov/pubmed/18353030

61. Berne B, Boström A, Grahnén AF, Tammela M. Adverse effects of cosmetics and toiletries reported to the Swedish Medical Products Agency 1989-1994. Contact Dermatitis [Internet]. 1996 May [cited 2017 Feb 21];34(5):359–62. Available from: http://www.ncbi.nlm.nih.gov/pubmed/8807231

62. Taylor B, Wadsworth M, Wadsworth J, Peckham C. Changes in the reported prevalence of childhood eczema since the 1939-45 war. Lancet. 1984;324(8414):1255–7.

63. Simpson CR, Newton J, Hippisley-Cox J, Sheikh A. Trends in the epidemiology and prescribing of medication for eczema in England. J R Soc Med [Internet]. 2009 Mar 1 [cited 2017 Feb 20];102(3):108–17. Available from: http://jrsm.rsmjournals.com/cgi/doi/10.1258/jrsm.2009.080211

64. Burd RM. Psoriasis: a general overview. Br J Hosp Med. 2006;67:259–62.

65. Prescott SL, Tang MLK. The Australasian Society of Clinical Immunology and Allergy position statement: summary of allergy prevention in children. Med J Aust. 2005;182:464–7.

66. Srinivas G, Möller S, Wang J, Künzel S, Zillikens D, Baines JF, et al. Genome-wide mapping of gene–microbiota interactions in susceptibility to autoimmune skin blistering. Nat Commun [Internet]. 2013 Sep 17 [cited 2017 Feb 20];4:2462. Available from: http://www.nature.com/doifinder/10.1038/ncomms3462

67. Asher MI, Montefort S, Björkstén B, Lai CK, Strachan DP, Weiland SK, et al. Worldwide time trends in the prevalence of symptoms of asthma, allergic rhinoconjunctivitis, and eczema in childhood: ISAAC Phases One and Three repeat multicountry cross-sectional surveys. Lancet [Internet]. 2006 Aug 26 [cited 2017 Feb 20];368(9537):733–43. Available from: http://www.ncbi.nlm.nih.gov/pubmed/16935684

68. Shaw TE, Currie GP, Koudelka CW, Simpson EL. Eczema Prevalence in the United States: Data from the 2003 National Survey of Children's Health. J Invest Dermatol [Internet]. 2011 Jan [cited 2017 Feb 20];131(1):67–73.

Available from: http://www.ncbi.nlm.nih.gov/pubmed/20739951