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The Implementation of Exercise for Chronic Kidney Disease and Dialysis Patients

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While commonly known to be the organ that helps with urine production within the human body, the kidney plays one of the most crucial roles in maintaining homeostasis. Homeostasis is seen as the body's ability to maintain its content at levels deemed most favorable. It is seen as one of the primary pathways for the body to regulate various levels of minerals, water, organic and inorganic molecules. This function plays a critical ongoing role as it filters through about 200 quarts of blood every 24 hours (Kidneys Work, 2017). Aside from the filtration capacity, the kidney also helps to maintain regulation of other body components such as blood pressure through the impacts of fluid retention, hormone regulation, Vitamin D production and assisting in red blood cell production (Kidneys Work, 2017).

When establishing all of the roles the kidney has on keeping humans healthy, there is the question of how does the body cope when a patient is diagnosed with kidney failure. One of the more common treatment options that allows the body to continue to function without a kidney is by beginning a patient on a form of dialysis. However, as with any treatment, there will always be a list of side effects. In hemodialysis, the most common type of dialysis treatment used in the United States, it is often associated with many common side effects which primarily negatively impact abdominal mineral levels, bone metabolism, and fluid balances (Kaplan, 2016) (Yamamoto et al, 2018). In a study completed by Yamamoto et al., and by Adragao et al., it was highlighted that the parathyroid hormone (PTH) increases within the body in dialysis patients, leading to an elevated risk of mortality mainly due to decreases in

bone volume (Yamamoto et al, 2018) (Adragao et al, 2009). It is also indicated that patients who are commonly on dialysis usually lack calcium and phosphate in the system while PTH is increased (Bleyer, 2020). It is primarily because of this where many complexities arise in many end stage chronic kidney disease (CKD) patients and those who have started dialysis.

While there are many medical approaches that can assist in the side effects of dialysis, there has been a recent trend to investigate the impact physical exercise can have for CKD and dialysis patients. Physical exercise has been generally known to positively affect the body. This paper will begin by investigating the overall benefit exercise has to the general body. It will then dive into determining the impact of different types of exercises impacting the kidney and probe how such effects compare to those near or already on dialysis. By researching each point, it will allow us to compile the information and touch upon the importance of diet regulation for kidney failure patients and how it can significantly play a role in treatment.

Main Benefits of Exercise

For the purposes of this paper, exercise is any form of dedicated physical activity that is done by the body in which is seen apart from daily normal activities (Exercise, n.d.). The implication of exercise can be seen to have a broad spectrum of benefits which can be categorized as physical and mental benefits. Today, the implementation of exercise is seen as one of the primary methods of curbing many rates of mortalities, bringing many physical benefits, as it targets risk factors that are associated with sedentary lifestyles such as hypertension, cardiovascular disease, obesity and diabetes

(Ross et al., 2016). In a study completed by Pedersen and Saltin, they completed a thorough literature review of the many benefits exercising can have on many chronic diseases (Pedersen & Stalin, 2015). Some of their most notable findings included the benefits of curbing obesity as they had shown from a study of 3476 obese or overweight participants who participated in physical activity and concluded that not only was there a significant reduction in just bodyweight and body mass index (BMI) alone but it also delivered positive effects on the risk factors for cardiovascular disease. Such cardiovascular and metabolic diseases that were also investigated by Pedersen and Saltin were hypertension, hyperlipidemia, and diabetes mellitus type 1 and type 2, while all showed significant improvements following participants undergoing exercise programs. (Pedersen & Stalin, 2015).

While cardiovascular and metabolic health is often associated with benefits from physical exercise, many studies have shown that other body systems can also be directly impacted. In a study completed by Schwartz et al. patients diagnosed with non-cardiovascular or non-metabolic diseases such as several forms of cancer have shown to benefit from exercise programs as it allows them to increase their energy reserves, allowing less worsening fatigue following treatments such as chemotherapy (Schwartz et al. 2017). This approach showed to be successful for various types of procedures as well including lymphedema, peripheral neuropathy, breast reconstruction, the patency of central lines, and a variety of ostomies. Each of the approaches noted that the prescription of exercise played a vital role to ensure greater benefits for the patient (Schwartz et al. 2017). In a separate study completed by Metsios

and George, the skeletal system also showed positive effects from physical exercise. In their investigation, multiple studies relating to rheumatoid arthritis showed that anti-inflammatory effects increase through exercising, allowing for a reduction of pain in both acute and long term approaches (Metsios & George, 2018). By observing these multiple studies, it allows the understanding that physical exercise is not only beneficial for cardiac or metabolic health, but the impact of it should be investigated in various possible approaches as there is a strong correlation that physical activity does have the potential to be beneficial in various systems and diseases.

Having investigated the physical benefits, there have also been numerous studies showing how beneficial exercise can positively affect the mental state of the body as well. Revisiting Pedersen and Saltin's study, they had also investigated multiple psychiatric and neurological diseases by reviewing how physical activity assisted in the betterment of such patient populations. They explored mental states such as depression, anxiety, stress along with disorders dementia and Parkinson's disease. In each of these investigations, there was an overall message through the literature review that was conducted. The incorporation of physical exercise allows positive feedback to be initialized allowing the mobilization of homeostasis by releasing hormones such as endorphins or dopamine (Metsios & George, 2018). Neural adaptations are also seen to be strengthened, assisting in various neurological diseases such as multiple sclerosis (Metsios & George, 2018). Many studies also support the correlation made between mental health and exercising. One example supporting this correlation can be found in the study conducted by Chekroud et al. where the authors investigated 1.2 million

participants between 2011 and 2015 as a cross-sectional study and concluded that those who were in the exercising group had a 43.2% improvement by having fewer poor mental health days in a month than those who did not exercise (Chekroud et al., 2018). It is important to note that the participants were otherwise matched for several physical and sociodemographic characteristics and had resulted in a significant p-value < 0.0001.

By comparing all the studies and literature reviews completed, it allows us to understand that the implementation of physical exercise has been found to be overall very beneficial to many aspects of the human body. Not only does it benefit the well-understood concept of aiding with cardiac health, but it also contributes significantly to other body systems physically and mentally. With having this understanding established, it helps us to institute the importance of needing to investigate how physical activity could possibly contribute to dialysis patients as it most likely plays an important contribution to this patient population as well.

Effects of Exercise (Endurance and Resistance Training) on Kidney Function

When investigating exercise and the effects it can have, it is important to differentiate what the mode of exercise is primarily targeting. As classified by the National Institute of Health (NIH), there are four categories that exercise can be classified as, endurance, resistance, balance, and flexibility (4 Types of Exercises, 2019). As this paper is concentrating on the physiological aspects of kidney function, it will primarily focus on endurance and resistance training effects as these methods are

the primary modes of exercises that impact the physiological functions of the body (Alabinis et al. 2003).

Endurance exercise is a form of physical activity that concentrates on increasing the pulmonary and cardiac work output through increased respiration and heart rate (*Endurance Exercise, n.d.*). With the increase in blood flow, allows the body to adjust for the difference in both acute and long term processes. Concentrating on the two primary functions of the kidney, filtering blood through urine production and homeostasis of blood pressure, it has been noted the implementation of endurance exercises has resulted in benefiting both of these physiological systems. In a study completed by Conboy et al. the impact of endurance training on renal vasoconstriction and orthostatic stress was investigated. The study consisted of eighty patients who had gone through an eight-week endurance training program. The group had their blood pressure, heart rate, and renal blood flow measured during a head tilt test before and after the program. The findings revealed that following the tilt table test, post-training, there was not a significant difference in renal blood flow and renal vascular conductance, while there was one pre-training. Having this pre-training decrease in vasoconstriction during endurance training, it drew the conclusion that endurance training may lead to an orthostatic challenge and may contribute to training-induced orthostatic intolerance (Conboy et al., 2018).

This was not the only instance where endurance training was seen to have a negative response on the kidney. According to a study completed by Bongers et al. endurance training is seen to increase the rate of kidney damage. This was done by

conducting a controlled trial where participants were prescribed different levels of endurance training. Their results indicated that with the sixty subjects tested, the higher amount of endurance that was prescribed, the higher the level of biomarkers for acute injury increased (Bongers et al., 2017). In the research conducted it was reasoned that as the body becomes more dehydrated, kidney changes such as decreased renal perfusion, increased glomerular permeability, and a decreased filtration ratio can potentially be the cause for kidney injuries (Bongers et al., 2017). The physiological reasoning behind this occurrence can be seen in Cheuvront et al. study where they indicated that the endurance training can lead to an imbalance of homeostasis, primarily through dehydration and electrolytes compensations (Cheuvront et al., 2010).

While endurance exercise can be seen to play a negative impact on the preservation of the kidney itself, one of the more common benefits that are seen with endurance training is the reduction of blood pressure, a primary cardiovascular risk factor. Blood pressure, while associated with the cardiovascular system, is primarily maintained by two pathways related to the kidney's capacity of water retention. These two pathways are the antidiuretic hormone (ADH) pathway and the aldosterone pathway. ADH is composed within the pituitary gland, which is then sent to the kidney. It modifies the collecting duct of the nephron to be more permeable to water, allowing more water intake into the body. Aldosterone works in a similar capacity, however, it is formed in the adrenal cortex and regulates blood pressure through sodium concentrations which allows water to be balanced through the process of osmosis. By having blood pressure be regulated directly by the kidney it allows us to make a

connection to how the kidneys behave when going through endurance training with blood pressure being a marker of measurement.

A study by Chen et al. explored the effects that endurance exercise can have on blood pressure regulation. Their study was a meta-analysis of randomized controlled trials was conducted on 1286 patients who all had a history of coronary artery disease. The participants had an endurance training intervention (8-12 weeks) which resulted in having a significant reduction in resting systolic blood pressure (Chen et al., 2016). The study did not include any significant findings for diastolic blood pressure, however, this absence of change is usually expected (Kravitz, n.d.). By seeing these results, while the reduction of resting blood pressure can be contributed to an increased heart function, requiring less work to pump the same amount of blood it comes the question of how does the impact of exercise stimulate these blood pressure systems in allowing blood pressures homeostasis (Exercise Is Medicine, 2019). During exercise, it is important to realize that blood volume decreases due to the loss of water. In order to deal with this loss, both of the blood pressure systems should be activated in order to allow an increase in the amount of water uptake (Borer, 2013). While endurance training allows the cardiovascular system to implement improvements, the kidneys have to compensate during such training in order to meet demands. It is with this need of increased demand that kidney function can be seen as being more strained during such methods of training as more pressure is placed on them to ensure that homeostasis is kept. With more intense exercises kidney damage symptoms such as red blood cells in the urine sample can also be indicative of overworking the kidneys during exercise

(Poortmans, 1984). Overall, it shows that while endurance training may benefit many different systems in the body, it can commonly overall have a negative effect on the kidneys and its functions.

While endurance exercise primarily focuses on cardiovascular health, resistance training has a different approach where it primarily focuses on developing the muscles themselves by allowing the muscles to work against a type of force (gravity, another object, or a person applying resistance) (Department of Health & Human Services, 2014). With this approach, it can be noted that there is not much stress placed on pumping the blood flow, which in turn would put less stress on the blood filtration capabilities on the kidneys. With this in mind, many studies have investigated how resistance training specifically impacts kidney function. Overall it is seen that resistance training is more beneficial for the kidney. One of the studies completed by Watson et al. investigated how feasible was resistance training in CKD patients. They had conducted a randomized controlled feasibility study, in which participants would go through eight weeks of a program consisting of resistance training (Watson et al., 2015). Upon completion, the participants were compared to their control group to see how much weight the participants were able to lift. The reason such a measure was being investigated was because loss of proteins through the kidney is a common complication of CKD, resulting in the inability to retain muscle mass (Wang & Mitch, 2014). By comparing how much was being lifted helps to establish if any protein retention was done, indicating an improvement in kidney function. Watson's study showed that there

was a significant difference, with a p-value of <0.001 indicating a good intervention model.

As resistance exercising focuses on muscle building, there have been many similar studies to Dr. Watson's which look at similar protein-related markers that help to see if there is kidney improvement in retaining proteins for the body. Dr. Balakrishnan et al. conducted a similar study in which they referenced the amount of mitochondrial DNA (mtDNA) in a randomized control trial where one group of CKD patients went through resistance training. It was found that the group that received the resistance training showed higher levels of mtDNA, suggesting higher rates of mitochondrial biogenesis, allowing more muscle build-up and less protein being lost from the kidney. The team concluded that resistance training can suggestively reduce or halt the rate of decline of the kindeys (Balakrishnan et al., 2010).

While the loss of protein has been shown to be reduced through resistance training, studies have also gone in-depth to see how the rest of the renal system in the kidney gets impacted by such training. Spada et al. looked into biomarkers of the renal component of the kidney to investigate how the levels of biomarkers get impacted. The study investigated fifty-eight healthy volunteers who were instructed to complete a high-intensity resistance training session. Following the procedure, blood samples were obtained after two and twenty-four hours measuring various kidney function-related markers. A urine sample was also collected. The results indicated significant elevations of creatinine kinase, myoglobin, serum creatinine, microalbuminuria and urinary biomarkers that usually indicate kidney tubular injury. Such elevations suggested that

muscle and kidney damage took place (Spada et al., 2018). By comparing the data from the resistive training investigation, it allows us to draw the conclusion that while there are some benefits to resistance training, it is important to make sure that the right load of resistance training is being completed as there is a fine balance of the amount of training, because if higher loads, or intensity increases, it can lead to more damage than benefits.

Overall, by observing the effects endurance and resistance exercises can have on a range of non-dialysis patients, it can be determined for the most part that both types of exercise do not deliver significant positive effects to the kidney. Through the studies investigated, the primary reason was due to the exertion placed on the kidney that allowed damage to become imminent. While resistance training did pose some positive effects, further investigation to determine the proper load and intensity is needed in order to maximize the benefit and reduce the risk.

The Effects of Exercise on Patients Undergoing Dialysis

For an individual who was diagnosed with CKD, one of the last options that are left on the table is the implementation of dialysis following the loss of 85-90% of the kidneys with a glomerular filtration rate (GFR) for less than 15 (Dialysis, 2018). While the primary function of dialysis is to remove waste, salt, extra water (allowing blood pressure regulation) and keeping a safe level of certain chemicals in the blood, such as potassium, sodium and bicarbonate, there are some things that disrupt the body's homeostasis capabilities more severely (Dialysis, 2018). In between sessions, there are three biomolecule levels that are measured to indicate how urgent a patient's need is for

dialysis: acidosis, hyperkalemia, and hyperphosphatemia (Bleyer, 2020). Many studies have been conducted to see how such biomarkers are impacted in dialysis patients to see if physical exercise can affect the severity of such levels.

Hyperkalemia is claimed to be one of the most dangerous symptoms presenting in dialysis patients, in between sessions, as it can only be filtered out when a patient goes through with treatment. Hyperkalemia can cause severe muscle fatigue, including the heart as a result showing clinical manifestations of electrocardiograph (ECG) abnormalities like arrhythmias and more drastic cardiac episodes such as cardiac arrest (Mount, 2020). Clark et al. investigated the subject matter by looking into potassium levels in hemodialysis. Their study pointed out that vigorous exercising often leads to substantial spikes of potassium in the body due to the fact that potassium is the primary product of when the muscles contract (Clark et al., 1996). Knowing this physiological phenomenon, they investigated how hemodialyzed patients compare to healthy participants with their body capability to work with the influx of exercise. Two groups were mobilized where one group consisted of hemodialysis patients and one control group. Both groups proceeded to complete an endurance exercise session. During this session, potassium levels were monitored. The study results showed that while initial potassium levels were higher in the dialysis patients, their pattern of increase during exercise and decrease post-exercise were the same. However, while the patterns were the same, it was noted that the dialysis patients also had increased amounts of basal norepinephrine, and higher basal insulin both during and post-exercise. Having seen these other changes, researchers concluded the body does have the capacity to

compensate for the influx of potassium in dialysis patients. Seeing the response, it was determined that dialysis patients actually have a higher response to exercise as the body was able to compensate for the influx of potassium with stronger effects and without having any renal impairment (Clark et al., 1996). It can be concluded from this study that exercising does not have a negative adverse reaction to the body, as even though the kidneys may not be able to clear out the potassium, the potential for hyperkalemia is maintained through other pathways. Having a greater reaction to exercise can allow us to draw the conclusion that exercise benefits the body in the long and short run.

Overall, the implementation of exercise for dialysis patients, commonly known as *Intradialytic Exercise*, has been a widely accepted practice in the field of medicine but not as widely practiced in North America (Parker, 2016). There are many studies being conducted across the globe that are continuing to explore how dialysis patients are, clinically, to the implementation of exercise. Aside from hyperkalemia, hyperphosphatemia is also a major concern in dialysis patients. Salhab et al. investigated whether or not the implementation of exercise has an impact on phosphate levels in dialysis patients (Salhab et al., 2019). The study was an experimental intervention on a group of patients undergoing hemodialysis. They were prescribed with 45 minutes of moderate-intensity aerobic intradialytic exercise per dialysis session for a period of twelve months. Their phosphate levels were measured three times during each session: baseline, post-intervention, and follow-up. After obtaining results and conducting a statistical analysis, it was concluded that there was no significant change

in phosphate levels in the patients when compared to pre-exercise (Salhab et al., 2019). With no significant changes in phosphate levels, it was determined that aerobic exercise can potentially be beneficial for hemodialysis patients (Salhab et al., 2019).

One of the main benefits that can be predicted from this study is that by knowing this, dialysis patients have a way of maintaining or even increasing their bone mineral density. Hyperphosphatemia has the ability to cause a decline in CKD patients primarily because levels of phosphate are in homeostasis with bone minerals such as calcium and vitamin D (*High Phosphorus, n.d.*). When high levels of phosphate are present, the body compensates through osteoclastic activity, reducing the bone mineral density in order to supply adequate levels of both vitamin D and calcium into the blood. Exercise has been a common method in regards to improving bone density. Marinho et al. reported that after conducting a randomized controlled trial where one group of participants diagnosed with CKD received resistance exercise and one group remained a control that after conducting dual-energy x-ray absorptiometry on the patients, the exercise group presented with less osteopenia and osteoporosis (Marinho et al., 2016). Knowing from Salhab et al. study that phosphate levels are not impacted through exercise, it allows us to implement Marinho et al. study knowing that by prescribing the exercise, it will help to combat the potential reduction of bone mineral density while knowing that not much harm is possible.

The bicarbonate buffer system (Image 1) is seen as an important buffer system in place of the body, allowing the body to maintain its physiological pH of 7.4. The respiratory system plays the most significant role in manipulating the equation as the

carbon dioxide made as body waste helps to maintain the pH by establishing a respiratory rate. What is less commonly known is that the kidneys also play an important role in excreting excess nonvolatile acid, and helping to replace balance by restoring bicarbonate

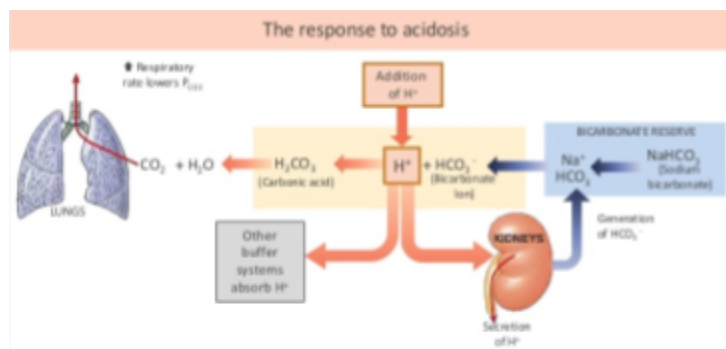


Image 1: The bicarbonate buffer system equation showing the compensatory mechanisms in the regulation of Plasma pH (The Response to Acidosis, n.d.).

(Kovesdy, 2020). With the diagnosis of CKD, this specific homeostasis model becomes disrupted as an accumulation of acid will generate due to the inadequate capacity that the kidney holds with reduced functionality. For our blood, the generation of acid is notably coming as a byproduct from exercising muscles producing lactic acid as oxygen depletion occurs. Knowing the basic stem of acid creation, the question of which type of exercise can produce the least amount of lactic acid. The incorporation of aerobic and anaerobic endurance exercise can be seen as an obvious culprit in generating lactic acid. Once the body runs out of oxygen, or is starting to work with no oxygen, lactate can easily be generated through anaerobic glycolysis or aerobic metabolism. However, as Farrell et al. studies indicate, that initially, unconditioned individuals will generate lactate faster as compared to physically fit individuals (Farrell et al., 2018). The study further went on to indicate that overall, "when aerobic exercise is supplemented with muscular endurance training metabolic adaptations occur that result in the delay of the onset of blood lactate accumulation" (Farrell et al., 2018). Knowing the benefits of aerobic exercise, the importance of implementing it helps to ensure the body is able to

maintain its other components that usually become impacted within dialysis patients. However, with the kidneys shut down, one of the most important things that should be monitored is the accumulation of blood lactate during exercise. While studies are yet to be completed about this, it can be theorized that if a dialysis patient is starting with endurance training, it should be done under small, less intense sessions, allowing for only a small build-up of blood lactate allowing the levels to stay within normal limits until the patient undergoes dialysis. As the patient continues to become fit, more intense sessions can be completed as a higher resistance of lactate production will occur, allowing more capacity for endurance exercise.

Resistance training has a different approach when looking at the utilization of oxygen reserves as there is less of an oxygen demand when compared to endurance training as the cardiovascular system is not as strained. While resistance as a whole can be seen as more beneficial when compared to endurance, there are specific types of resistance training that are more beneficial than others. Marston et al. investigated blood lactate levels and sought a correlation it can have between hypertrophic exercise and strength exercise (Marston et al., 2017). It is important to note the difference between hypertrophy and strength exercise. While both can be classified as resistance training, hypertrophy exercises concentrate on increasing the muscle mass itself while strength exercises look at increasing the amount of force that can be generated by a specific muscle mass (Stull, 2017). While the exercise itself is the same for both forms of exercises, differences appear in intensity, repetitions, sets and resting time between sets (Stull, 2017). The study looked at how certain types of resistance exercises can

impact certain neurotrophic factor levels to see if similar results will occur. While the study was primarily looking for the presence of neurotrophic factors, the study did also collect blood lactate levels. The results indicated that lactate was positively correlated with hypertrophic exercise $r=0.70$; $p<0.01$ but not with strength exercise $r=0.18$; $p=0.56$ (Marston et al., 2017)

Comparing the differences between endurance and resistance training, it was based on which one depletes its oxygen reserve the fastest. However, knowing that both endurance and resistance exercises are important for maintaining the overall health of the body, it comes back to the theory stated earlier on how we can implement endurance training while remaining within the normal blood lactate limits. Khalid et al. investigated this matter by looking at the effectiveness of resistance interval training versus aerobic interval training in regards to oxygen uptake (Khalid et al., 2019). While their study was looking at patients with a history of a myocardial infarction they were able to determine how each exercise would compare directly to oxygen capacity. A single-blinded randomized controlled trial was conducted with 26 stable patients with a history of myocardial infarction (Khalid et al., 2019). The patients were divided into groups where different exercise methods were prescribed. Following six weeks of training, cardiac outcomes and aerobic capacity were recorded. The study showed that resistance training with a combination of aerobic interval training was the most effective in increasing aerobic capacity (Khalid et al., 2019). By comparing this result to the suggested theory we can see that with deconditioned patients on dialysis, one of the best ways to implement both resistance and endurance training would be by

implementing resistance training with minimal endurance training. This will, as suggested by Khalid et al., increase the aerobic capacity (Khalid et al., 2019). By having the increased capacity, it allows for the body to reduce the need for lactate fermentation, reducing blood lactate levels in the body. By slowly increasing the capacity, it allows for gradual slight increases in endurance training as tolerance of the exercise increases (Khalid et al., 2019). By using the results from Khalid et al study of increasing aerobic capacity and aerobic exercise tolerance, we can apply the findings to the basic functions of energy production through glycolysis. By increasing the aerobic capacity the body is able to have more oxygen to work with. This allows for an increased dependency on the aerobic pathway of glycolysis and not the anaerobic pathway, allowing for less lactic acid production and a smaller decrease in blood pH. This aids with staying within the physiological pH limits and allows exercise to still be implemented in dialysis patients while not putting a patient at risk for acidosis.

It is important to note the differences between the risk and benefits of exercising in a CKD patient who has started and who has not started treatment with dialysis. One of the overall ideas that was discussed earlier in non-dialyzed patients, which still presents as a disadvantage to dialysis patients as well, was the potential of causing more harm as additional stress is placed on the kidneys as one would increase exercising. However, with a patient who is on dialysis, the need to consider the stress on the kidney can be minimized as kidney function is already significantly reduced and there is now another means for the body to filter out its blood. It is because of the assurance of dialysis being available, the benefits of implementing exercise potentially

outweighs the risk as the kidney is not as much of a concern anymore. Following dialysis the focus of preventing additional kidney damage shifts to helping to make sure additional complications do not incur. This is the reason why Salhab et al. and Clark et al. studies indicating no changes in hyperkalemia and hyperphosphatemia following exercise is important as it helps us to understand that no additional damage can be done and that only improvements can persist from such a stage.

The other main concept that we are aiming to accomplish with Salhab et al., Clark et al., and Khalid et al. 's findings allow us to understand how we can manipulate our actions in order to minimize specific strains to the kidney. With dialysis patients, the approach that has to be understood is that kidney functions are near nonexistent in between dialysis sessions. It is because of this, in order to reduce the occurrence of CKD symptoms such as hyperkalemia, hyperphosphatemia, and acidosis while ensuring we are maintaining the rest of our body, such studies allow us to establish a baseline of what happens during exercise. Using these results, specific exercise prescriptions can be established that allow the optimal conditioning while enduring less risks towards the kidney and the rest of the body.

The Significance of Diet Regulation for CKD Patients

By observing the implications that high levels of phosphate, acid, and potassium can cause patients and how the body has various ways to produce such biomolecules, in order to make sure that the studies indicating general trends in exercise, it is important to realize that such conclusions are based without the additional investigation of diet and how it can create additional limits within the finding suggestions. In a paper

published by Carnauba et al. it was indicated how the excessive consumption of “acid precursor foods” such as phosphorus and protein can lead to a slight drop in blood pH as it can contribute to low-grade metabolic acidosis (Carnauba et al., 2017). While it may remain within the normal range for healthy individuals, the study indicated how there are potential associations between acid diet loading and CKD patients. With the increase in acid with worsened kidneys, it allows an increase in ammonia production leading to increased levels of tubular toxicity and renal damage (Khalid et al., 2019). In dialysis patients, with almost zero kidney function, this becomes a more severe issue as with a build-up in acid, even prior to exercising it generates a greater risk of surpassing normal limits, impairing health.

The ingestion of potassium and phosphates are also seen in a similar light. Both phosphate and potassium are at risk for surpassing normal loads within dialysis patients. With potassium being a common byproduct of muscle contraction (Clark et al., 1996), the intake of more potassium can put patients at higher risk than where they were already at with only CKD. By increasing the levels of potassium in the system, it again creates a narrower window to implement exercise prescriptions as a lower intensity would be preferred to reduce the amount of potassium within the system. While phosphate was seen to not be impacted by the implementation of exercise, it does create the issue of increasing the rate of decreasing bone mineral density as additional calcium and vitamin D will be needed to compensate for the influx. Having such incidences can cause further complications such as increased chances of bone fractures or simply not having the capability to overcome the decreasing bone mineral

density through the implementations of exercise targeting an increase in bone mineral density. By observing the many negative implications that CKD and dialysis patients can have, it is important that aspects that are within control, such as diet are carefully considered (Kidney Diet, n.d.). That is why there are many guidelines that advocate the reduction of such biomolecules from the diet and they should be followed in order to allow the most room for improvement in quality of life and reduce further complications, especially for those who are on dialysis.

Conclusion

Overall, it can be observed that the introduction of exercise to the general population and to those with either CKD or on dialysis presents as a situation that needs to be approached with every detail being considered. While there are many instances that exercise can deliver a significant strain to kidney function there are also many instances as to why it is important to have it a part of a regular routine. With there being ample risk and benefits to implementing exercise specifically in CKD and dialysis patients, the prescription of exercise should take into consideration the risk and adjust to ensure that the benefits outweigh the risk. Having a gradual implementation of endurance exercising while having constant resistance training, for example, allows less of a chance for a spike in blood lactate levels as oxygen reserves increase, ensuring a less chance of a patient to overload on certain molecules leading to more complications or emergency dialysis. Patients, while implementing the exercise in an appropriate time frame, should also be aware of their dietary organization as it can contribute to the overall management of implementing exercises beneficial to overall care. Just like how

the kidney is responsible for maintaining homeostasis for the body, the approach of exercise has to be similar in order to make sure that everything is being taken care of.

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